Association of Schools of Construction of Southern Africa

The 17th Built Environment Conference

Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster & Development: The Final Chapter

09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa

Conference Proceedings
17th Built Environment Conference – Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster & Development: The Final Chapter

09 – 10 October 2023
CSIR International Convention Centre, Pretoria, South Africa

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PUBLISHED BY
Association of Schools of Construction of Southern Africa, Postnet Suite 107, Private Bag X5516, Scottburgh 4180

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ISBN number: 978-0-7961-2424-1

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9 October 2023
PREFACE

The Association of Schools of Construction of Southern Africa (ASOCSA) Built Environment conference series in its 18th year of existence continues to be one of the major cutting-edge built environment conferences on the African continent. Since its inception in 2006, the blind peer reviewed conference proceedings have been referred to by both private and public sector policy and decision makers. The series produces a post-conference edition of the Journal of Construction, which is on the list of journals approved by the South African Department of Higher Education and Training (DHET) for subsidy. The conference series continues to be endorsed by the International Council for Research and Innovation in Building and Construction (CIB), one of the largest global built environment research organizations and recognized by the Australian Institute of Building (AIB). The conference provides an interactive international forum and networking opportunities among researchers, academics, administrators and practitioners, representing institutions of higher learning, government agencies, contracting organisations, consulting enterprises, financial institutions, and other construction-related organisations.

The 17th Built Environment Conference is an in-person event. Delivering a world-class conference is not novel for ASOCSA. The conference proceedings will be published by ASOCSA within a reasonable time after the conference once all audits and verifications have been completed. The authors of a selection of the best ten to twelve conference papers will be invited to rework their papers into book chapters that will be published in a Scopus, Compendex and Web of Science indexed edited book post-conference and titled, Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster, Development: A Final Look. This book will be published within 12-18 months after the papers in their correct format have been submitted. Papers will also be invited to be reworked for submission to the Journal of Construction.

OBJECTIVES

The 17th Built Environment Conference with its theme of Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster & Development: The Final Chapter has a range of interesting and cutting-edge peer-reviewed research papers addressing topical issues that affect the built environment not only in South Africa but in the regions beyond. This edition is the final one in the 3-conference series on these topics. Notwithstanding the ever-increasing challenging global economic environment with shrinking sponsorship budgets, the conference continues in the tradition of previous conferences in the series and provided an international forum with clear industry development and sustainability focus. This focus provides the opportunity for researchers and practitioners from developed and developing nations to deliberate topical current issues that impact the Built Environment.

The broad objectives of the conference are:

To provide a forum for multi-disciplinary interaction between academics and industry practitioners.
To disseminate innovative and cutting-edge practices that respond to the conference theme and outcomes, namely Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster & Development: The Final Chapter.
To provide a world class leading internationally recognized, accredited and SCOPUS-indexed conference for the built environment; and
To contribute to the existing built environment body of knowledge (BEBOK) and practice.

The conference organizers bring together in a single forum, a group of researchers and academics from the wide range of built environment disciplines that include engineers, architects, quantity surveyors, construction, and project managers. ‘Delegates’ and participants are drawn not only from South African institutions of higher education, government agencies, and other construction-related organizations but also from across the African continent and the United Kingdom.
CONFERENCE THEME AND OUTCOMES

CONSTRUCTION IN 5D: DECONSTRUCTION, DIGITALIZATION, DISRUPTION, DISASTER & DEVELOPMENT: THE FINAL CHAPTER

There is little doubt that the construction industry has experienced exponential change and development in recent years. The 17th Built Environment Conference as the final edition of the three-conference series on these topics will examine the selected cutting-edge concepts to determine their state of the art in the construction sector both in practice and academic research. This conference therefore seeks final responses to questions related to current conversations, debates, and empirical research on:

Deconstruction – the dismantling or ‘unbuilding’ of buildings to maximise reusing and preserving the demolished fragments and involves taking a building apart piece by piece, essentially reversing the order of its construction.

Digitalization – the conversion and transformation of construction business processes to use digital technologies and embrace the ability of digital technology to collect data, establish trends and make better business decisions.

Disruption – displacement of well-established construction technologies, techniques, or products to disruptively affect the normal operation or function of the construction industry while potentially creating a new industry or market. Artificial intelligence, virtual/ augmented reality, internet of things, blockchain technology, and e-commerce are some of the disruptive technologies that are significantly influencing the future of the construction industry.

Disaster – an occurrence that disrupts the normal conditions of existence and operation causing a level of suffering and challenge that exceeds the capacity of adjustment of the affected community and the construction industry.

Development – in the context of construction refers to an industry that possesses the vision, leadership and capacity to bring about a positive transformation of itself within a condensed period of time.

The conference includes papers that address, inter alia,

Current trends and developments
Policies
Legislation and regulations
Practices
Case studies.

The internationally peer reviewed, and edited conference proceedings that contains the full papers is aimed at contributing significantly to the body of knowledge relative to the science and practice of construction not only in South Africa but everywhere where the products of construction are produced even in these new challenging times of fear and uncertainty.

Prof Theo C. Haupt
Conference Academic Chair (2023)
Durban, South Africa
October 9, 2023
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While every effort is made to ensure accuracy in this publication, the publishers and editors make no representation, express or implied, regarding the accuracy of the information contained in these proceedings and cannot accept any legal responsibility or liability in whole or in part for any errors or omissions that may be made. The views expressed in this publication are not necessarily those of the publishers and editors, neither do they endorse or guarantee any claims made by the authors of the papers in these proceedings. The reader should therefore verify the applicability of the information or situations and check the references prior to any reliance thereupon.

ACKNOWLEDGEMENTS

The organizing committee of the 17th Built Environment conference, held at CSIR International Convention Centre, Pretoria, South Africa, is grateful to the Council of the Association of Schools of Construction of Southern Africa and member universities and individuals for supporting this conference through their valued contributions. Special thanks are also extended to our conference partners for supporting the conference. Without the support received, this conference and the further development and growth of the Association of Schools of Construction of Southern Africa (ASOCSA) with respect to its mission in the region would not be possible. Additionally, this support demonstrates the commitment to the further development of the body of knowledge relative to the science and practice of construction. This commitment is deeply valued and acknowledged. Additionally, this support demonstrates the commitment to the further development of the body of knowledge relative to the science and practice of construction. This commitment is deeply valued and acknowledged.

Further thanks are extended to Dr. Progress Chigangacha (Nelson Mandela University) and Dr. Mohlomi Raliile (Free State University of Technology) who worked tirelessly especially in the co-ordination of paper reviews. The organizing committee also wishes to acknowledge the selfless contributions of the Scientific and Technical Committee and panel of reviewers who ensured that each paper was rigorously refereed for inclusion in the conference proceedings and possible selection for inclusion in the published SCOPUS-indexed post-conference publication of the highest standard that satisfies the criteria for subsidy by the South African Department of Higher Education and Training (DHET).

The excellent support of our webmaster, Tamar Ellis in setting up and supporting the conference website and technical support during the conference itself is appreciated. The sterling contributions of Ferial Lombardo in the co-ordination and organization of the conference are acknowledged.

ORGANISING COMMITTEE

Prof Theodore Haupt, Nelson Mandela University and University of Wyoming, Conference Academic Chair
Dr. Progress Chigangacha, Nelson Mandela University, Conference Academic Co-Chair
Dr. Mohlomi Raliile, Free State University, Conference Academic Co-Chair
Mrs. Ferial Lombardo, Conference Secretariat

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ISBN number: 978-0-7961-2424-1
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**ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa**
PEER REVIEW PROCESS

To maintain and ensure the highest quality in the conference proceedings and comply with the requirements for subsidy of the South African Department of Higher Education and Training (DHET), a rigorous two-stage system of peer review by no less than two acknowledged experts in the field has been followed. In terms of this process, each abstract received was twice blind reviewed in terms of:

- Relevance to overall conference theme and objectives;
- Relevance to selected sub-theme;
- Originality of material;
- Academic rigour;
- Contribution to knowledge; and
- Research methodology.

Authors whose abstracts were accepted after a blind peer review process was completed were provided with anonymous reviewers’ comments and requested to submit their full papers noting and addressing these comments. Evidence was required relative to the actions taken by authors regarding the comments received. These resubmitted papers were twice blind reviewed again in terms of:

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

Authors whose papers were accepted after the second review were provided with additional anonymous reviewers’ comments and requested to submit their revised full papers. These final papers were only included in both the conference presentation schedule and the conference proceedings after evidence was provided that all comments were appropriately responded to, having been multiple peer-reviewed for publication. At no stage was any member of the Scientific and Technical Committee or the editor of the proceedings involved in the review process relative to their own authored or co-authored papers. The role of the editors was to ensure that the final papers incorporated the reviewers’ comments and arrange the papers into the final sequence based on the conference presentation schedule as captured on the conference proceedings and Table of Contents. Of the 46 abstracts originally received, only 33 papers were finally accepted for presentation at the conference and inclusion in the conference proceedings, representing an acceptance rate of 72%. To be eligible for inclusion these papers were required to receive one of three recommendations from at least two reviewers, namely:

- Accepted for publication
- Provisional acceptance provided minor changes / corrections are made
- To re-submit for publication provided author/s reconsider/s the areas of concern

Regards,

Theo C. Haupt
Conference Academic Chair 2023
Nelson Mandela University and University of Wyoming
October 2023

To whom it may concern,

Dear Author,

RELATIVE CONTRIBUTION OF ACADEMIC INSTITUTIONS TO THE 17TH BUILT ENVIRONMENT CONFERENCE 2023

On behalf of ASOCSA 2023, we confirm that the papers accepted for publication in the 17th Built Environment conference proceedings met the 60-40% conference policy.

A total of 33 (single or co-authored) peer-reviewed papers from 19 national and international universities were presented at the conference.

The total author affiliation breakdown for each of the papers are shown on Table 1.

Table 1: Breakdown of Authors and Affiliations

<table>
<thead>
<tr>
<th>Institution</th>
<th>1st Author</th>
<th>Co-author</th>
<th>Total</th>
<th>% By Institution</th>
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<tbody>
<tr>
<td>1 Ardhi University, Tanzania</td>
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<td>19 University of Wyoming</td>
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<tr>
<td><strong>Total</strong></td>
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<td><strong>60</strong></td>
<td><strong>93</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The final accepted papers are published in the conference proceedings with ISBN number: 978-0-7961-2424-1

Kind regards,

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
TAX BENEFIT

ASOCSA is a registered Public Benefit Organization as defined in Section 30 of the Income Tax Act and a registered Section 21 Company as defined in the Companies Act. Therefore, all donations made to ASOCSA will be fully deductible for income tax purposes and a section 18A certificate, for proof of deductibility will be issued to the donor upon receipt of the donation. The deductible donation is limited to 10% of the donors’ taxable income before providing for Section 18A and Section 18 deductions.

History

ASOCSA is not the first attempt to form a body that addresses, inter alia, matters of construction education and training. In the days of the Building Industries Federation South Africa and the National Development Fund there were regular annual meetings of the Heads of Departments that offered construction-related programs. Recognizing the two-tiered higher education sector in South Africa, there were separate meetings for universities and the former technikons. In the more recent past, the Chartered Institute of Building - Africa initially convened annual educators’ forums that did not quite fulfill the same function as the previous forums. However, during 2005 the very first meeting of University Heads of Departments drawn from all higher education institutions in South Africa met for the very first time since the re-landscaping of the sector in the same venue to discuss matters affecting construction, and particularly construction education in the country. This meeting was repeated in 2006 where the need was expressed for the establishment of a formal forum / association of universities to engage in discussion / debate / collaboration / promotion of matters of mutual interest and so ASOCSA was born.

Broad Aims

ASOCSA aims to be the professional association for the development and advancement of construction education in Southern Africa, where the sharing of ideas and knowledge inspires, guides and promotes excellence in curriculums, teaching, research and service. To achieve this aim ASOCSA is partnering with the construction industry to find ways to effectively represent the interests of both construction academic and industry practitioners. ASOCSA will offer a variety of programs and services designed to help its members serve their customers more effectively and succeed in an increasingly challenging environment of construction information management and technology. To this end ASOCSA provides a forum for the debate and discussion of issues of mutual interest to all industry stakeholders. For example, one of the tasks of ASOCSA will be supporting the development of curriculums that address the needs of the construction sector in the Southern African region. ASOCSA convenes an annual conference that is one of only two construction-related conferences previously accredited by the Department of Higher Education and Training (DHET) where construction academics and practitioners can interact relative to practical experience and the findings of relevant research. This conference series is endorsed and underwritten by the International Council for Research and Innovation in Building and Construction (CIB) as well as several major industry stakeholders.

The Journal of Construction which is accredited by the Department of Higher Education presently published electronically four times per year is the official journal of ASOCSA and in the past more than 5,000 complimentary copies were distributed to all industry stakeholders in the Southern African region. The production and distribution of practice notes and technical papers is a further endeavor to grow the partnership between academia and industry.

With respect to the Southern African region, ASOCSA is committed to the following:

Vision

To drive innovative construction related higher education

Mission Statement
To promote, facilitate, develop, and monitor the relevance and quality of construction related curricula, research, and graduates in conjunction with higher education institutions, industry and government.

**Strategic objectives**

The objectives of the Association are:

- to promote and facilitate the development of curricula for construction related programmes
- to assist with the accreditation of construction related programmes
- to hold an annual conference that acts as a forum for multi-disciplinary interaction between academics and practitioners
- to publish an accredited research-based journal and contribute to the built environment body of knowledge (BEBOK)
- to disseminate information dealing with construction education and related matters
- to develop and maintain closer links with industry and government
- to represent the collective views of its members
- to liaise with other organisations and persons to promote the interests of its members
- to promote and support relevant postgraduate research
- to provide bursaries to postgraduate students in accordance with set criteria

ASOCSA continues to seek opportunities to promote both academic and industry employment opportunities. Finally, ASOCSA intends to play a significant and supportive role in the accreditation of construction-related academic programs.

**Heads Forum meetings**

ASOCSA believes that meetings of the Heads of School and Departments of Construction in Southern Africa is a vital component of its functions and holds both formal and informal discussions with Heads during each conference. The annual Construction Education Summit series commenced in 2021 (CES21) is planned from 2023 to become a formal platform for engagement with all construction higher education stakeholders.

**International Affiliation**

ASOCSA has commenced discussions about closer collaboration with similar institutions such as the Associated Schools of Construction (ASC) in the United States, the Royal Institute of Chartered Surveyors (RICS), the Chartered Institute of Building (CIOB), Australian Institute of Building (AIB) and Council of the Heads of the Built Environment (CHOBE) in the United Kingdom. ASOCSA has entered a Memorandum of Understanding with the International Council for Research and Innovation in Building and Construction (CIB).

In summary, benefits of membership of ASOCSA which are self-evident include participation in meetings of the Heads and the CES series throughout the region, access to the Journal of Construction with reduced paper processing fees, reduced rates at all ASOCSA, MBA and CIB events, involvement at regional level with industry-academia forums, interaction and networking opportunities relative to, for example, collaborative research, curriculum development, external moderation of courses, and external examination.

**ASSOCIATION OF SCHOOLS OF CONSTRUCTION OF SOUTHERN AFRICA**

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**Journal of Construction Editorial Committee**

- Editor: Prof Theo Haupt, Nelson Mandela University
- Associate Editor: Mr Ferdinand Fester, Durban University of Technology

For more information on ASOCSA and its activities visit [www.asocsa.org](http://www.asocsa.org)
Dear Author

**PEER REVIEW PROCESS CONFIRMATION: 17TH BUILT ENVIRONMENT CONFERENCE: CSIR INTERNATIONAL CONVENTION CENTRE, PRETORIA, SOUTH AFRICA, 2023**

This serves to confirm that the following blind peer review process was strictly followed relative to this conference.

To ensure the highest quality in the conference proceedings and comply with the requirements for subsidy of the South African Department of Higher Education and Training (DHET), a rigorous two-stage system of peer review by no less than two acknowledged experts in the field has been followed. In terms of this process, each abstract received was twice blind reviewed in terms of:

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Sincerely,

Dr. Progress Chigangacha (Conference Co-Chair)
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An alternative sustainable walling material for building projects in construction industry

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ABSTRACT

Purpose
Autoclaved Aerated Concrete (AAC) is an eco-friendly and sustainable material. This study evaluates the acceptability and key drivers as a walling material.

Design methodology
Seventeen online questionnaires were sent via email to South African construction practitioners in five provinces and 99 questionnaires self-administered to construction professionals in Lagos, Nigeria. The statistical techniques used for analyses were frequency distribution, percentages, ranking, mean score and percentage mean unit.

Findings
The top four AAC block types used in building projects in South Africa are those AAC made using Ordinary Portland Cement (OPC) of grade 52.5, OPC of grade 42.5, Aluminum Powder (AP) or Rice Husk Ash (RHA), and Palm Oil Fuel Ash (POFA) or Pulverized Fuel Ash (PFA). The top factors influencing the use of AAC in Nigeria are its lightweight characteristics, ecological improvements, energy efficiency, adaptation to hot regions, excellent heat assimilation characteristics, good fire resistance, and adaptability to architectural flairs. Whereas, AAC is mostly used in South Africa due to its outstanding fire insulation properties, lightweight characteristics, energy efficiency, superior thermal absorption characteristics, adaptability to any type of architecture, eco-friendliness; and remarkable thermal conductivity.

Research implications
The research draws the conclusion that AAC block producers that manufacture AAC variations outside the four listed above would probably not grow in business since they would receive little support from construction practitioners.

Practical implications
Although lightweight characteristics is the most important driver for both nations, the relevance of drivers for the use of AAC blocks varies. This suggests that practitioners in both nations prioritize the block's lightweight properties, which could be preferred for tall projects due to lower costs for the foundation and other structural components.

Keywords: Autoclaved Aerated Concrete, Block, Drivers, Nigeria, South Africa, Sustainability.
1. **INTRODUCTION**

Global industries including construction strive to reduce energy and carbon emissions via various means and strategies (Nduka et al. 2019). Another key challenge issue in Nigeria is to reduce housing deficit through sustainable solutions, especially materials (Afolabi et al., 2019). Autoclaved aerated concrete (AAC) has proven to be a sustainable material capable of ameliorating the aforementioned global phenomenon and others. Aerated concrete is produced via a procedure that includes preparing the slurry, foaming or rising, cutting, and steam curing (autoclaving), during which the primary constituents interact chemically. Aerated concrete may be divided into two main groups, namely autoclaved aerated concrete (AAC) and non-autoclaved aerated concrete (NAAC), based on the techniques of curing. Curing is a significant aspect impacting the physical and mechanical characteristics of concretes in various categories (Desani et al., 2016). Earlier walling materials were mud bricks that had been sun-dried, however, burnt bricks were subsequently discovered with higher resistance to harsh weather, making them preferable to mud bricks (Oo & Hlaing, 2018). Heat is absorbed by fired or burnt clay bricks throughout the day and released at night. The kilning process has highlighted some sustainability issues due to energy consumption and greenhouse gas emissions, but it also has certain inherent sustainable qualities including durability and high thermal mass. According to Rathi and Khandve (2015), burnt clay bricks are not ecologically sustainable and should not be substituted for AAC blocks. In comparison to conventional structural building materials like concrete, wood, brick, and stone, AAC blocks have unmatched benefits such as being lightweight, workable, moisture resistant, eco-friendly, good water assimilation properties, permeable, reusable, not harmful, replenishable, high insulating, able to be recycled, strength, lasting, soundproofing, fire retarding, excellent thermal insulation, insect-proof, more cost-effective and eco-friendly (Rathi & Khandve, 2015; Oo & Hlaing, 2018; Pandey et al., 2018). Amidst these benefits, its usage as a walling unit on building projects in Africa is at infancy or non-existent. Thus, the objectives of this study are to assess the extent of AAC block adoption in South African construction projects and to determine factors that influence AAC block usage in Nigerian and South African construction projects.

2. **LITERATURE REVIEW**

AAC is one of the most preferred walling materials in Europe and its usage is expanding quickly in many other nations as well, unlike in Africa where its adoption still grapples. Pandey et al. (2018) corroborate that AAC is commonly used in Europe, and its use is expanding quickly in nations. AAC is used in a variety of building construction projects, including those that are residential, educational, commercial, hospitality, and healthcare related. As a result, it takes the place of environmentally unsustainable clay bricks.

Rathi and Khandve (2015) discovered that using eco-friendly AAC blocks instead of traditional red bricks might reduce building costs by up to 20%. The adoption of AAC blocks also results in relatively lighter members by lowering the dead load of the wall on the beams, which decreases the need for materials like cement, reinforcement, and sand by up to 50%. Oo and Hlaing (2018) posit that AAC is cheaper than traditional brick. In a similar vein, AAC block weighs less than ordinary brick when used to construct a wall with a surface area of 100 feet. Also, AAC blocks have superior quality and improved compressive strength to traditional brick.

According to Research and Market (2020), the market for AAC is being driven by the rising demand for environmentally friendly building materials in China, while AAC is extensively utilized in earthquake-prone Japan. In India, AAC, a recently approved green construction material, is utilized in place of traditional red clay bricks. Similar to this, AAC blocks are frequently utilized in South Korea to reduce building cooling and heating demands. The investment climate for the commercial building has improved in Australia, which will increase demand for AAC. Germany also wants to achieve a nearly climate-neutral building stock by 2050 throughout Europe. The UK market is driven by modifications to building codes and strategies to enhance thermal and acoustic performance. Buildings today frequently employ AAC, which was initially developed in Scandinavia. AAC is in
great demand in Russia despite a general drop in construction activity. The need for AAC building materials is rising in Poland, meanwhile, as residential development expands. Due to its ability to absorb moisture, AAC is becoming more and more in demand in North America, namely the US, and is widely utilized in flood-prone locations. AAC has gained widespread acceptance in Canada due to its ability to withstand heat. Mexico's rapidly expanding infrastructure is luring top AAC producers to the nation. AAC blocks are the most often utilized AAC material in Turkey, the Middle East, and Africa. Nonetheless, AAC is acknowledged and authorized for usage in several notable projects around the UAE. Several existing and prospective infrastructure projects in Saudi Arabia and South Africa (SA) are predicted to increase the need for AAC materials. Brazil is seeing an increase in demand for AAC materials in the construction of infrastructure in South America. The AAC market is expanding in Argentina owing to the country's optimistic prognosis for the building and construction sector. Although developing countries are making efforts to onboard green technologies for sustainability, energy efficiencies and conservation (Omuh et al., 2018); the adoption of sustainable materials such AAC is still far-fetched. The significance of this study is thus to shed lights on the improvement of AAC adoption and allied materials.

3. RESEARCH METHOD

Survey research design was used for this study in Nigeria and South Africa. Nigeria and South Africa were chosen because there was a South African firm in Nigeria in the past that manufactured and introduced the AAC blocks and used on some projects in Lagos. Nonetheless, the company had to relocate to South Africa due to lack of patronage. Construction professionals in Lagos, Nigeria, were selected using convenience sampling technique, while snowball sampling technique was engaged for the South African construction professionals in five provinces. The questionnaire included closed-ended questions on the research's objectives. Twenty AAC block variants coined from literature were provided, as well as the level of adoption of each version in previous ten projects executed by the respondents in South Africa; this was not undertaken in Nigeria because AAC is not presently used by professionals in Nigeria. Each project was measured a scale of 1 to 10, where respondents were requested to select any version that had been used on 10 projects executed in the past 5 years. Additionally, the importance of 26 AAC drivers were examined on a scale of 1 to 5, not important to most important. One hundred and forty-five questionnaires were issued to professionals in Lagos, with 68.3% response rate; while 17 questionnaires were gathered in SA from practitioners who are familiar with the material and involved in its usage on building projects in five provinces. The analytical tools used in the study are frequency, percentage, mean score, ranking and percentage mean usage (%PMU).

\[
PMU \text{ of each variant } = \frac{\text{Number of times a variant was used (F)}}{\text{Total number of times AAC blocks were used on projects (T)}} x 100\%
\]

4. FINDINGS

4.1 Demographic Characteristics of Respondents

In Nigeria, architects, builders, civil engineers and quantity surveyors were 7.1%, 38.4%, 45.5% and 9.1% respectively. The majority of the participants held civil engineering degrees, according to this finding. In addition, 10.1% of participants have a Higher National Diploma (HND), 55.6% have a bachelor's degree in science (B.Sc.), while 31.3% and 3.0% of the respondents have masters and doctoral degrees respectively. More than 75% of the respondents have work experience above 5 years, implying they are knowledgeable to provide responses to the questions. Furthermore, 31.3 percent of the respondents worked for consulting firms, 45.5 percent for contracting firms, 5.1 percent for client firms, and 18.2 percent for design and build firms. In addition, 47.5 percent...
were medium-sized, 43.4 percent were small-sized, while 9.1 percent of the companies were large sized. Besides, 60.6 percent of the companies are held by indigenous people, 5.1 percent are fully foreign-owned, and 34.3 percent are a mix of both. Also, in all, 27.3 percent of the organizations of the respondents engage in new construction work, 5.1 percent in rehabilitation and refurbishment work, and 67.7 percent engage in the general contracting activity.

Similarly in SA, about 74% of the respondents have work experience above 5 years; while large-sized, medium-sized and small-sized firms were 23.5%, 35.3% and 41.2% respectively. Furthermore, 23.5% of participants' firms handle new construction, 5.9% handle renovation/refurbishment, and 70.6% execute general contracting. The respondents reside in the Western Cape, Gauteng, the Eastern Cape, Free State, and KwaZulu-Natal.

4.2 Adoption of AAC Blocks in South Africa.
Table 1 sheds light on AAC variants' adoption in descending order, eight variants are used in different levels while twelve are not used at all in SA. It also shows that AAC with 52.5 grade OPC is the most used variant in SA.

<table>
<thead>
<tr>
<th>AAC Variations</th>
<th>F</th>
<th>% MU</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.5 grade OPC AAC</td>
<td>85</td>
<td>31.5</td>
<td>1</td>
</tr>
<tr>
<td>42.5 grade OPC AAC</td>
<td>74</td>
<td>27.4</td>
<td>2</td>
</tr>
<tr>
<td>RHA or AP AAC</td>
<td>43</td>
<td>15.9</td>
<td>3</td>
</tr>
<tr>
<td>PFA or POFA AAC</td>
<td>43</td>
<td>15.9</td>
<td>3</td>
</tr>
<tr>
<td>Silica Fume /Fly Ash AAC</td>
<td>11</td>
<td>4.1</td>
<td>5</td>
</tr>
<tr>
<td>32.5 grade OPC AAC</td>
<td>9</td>
<td>3.3</td>
<td>6</td>
</tr>
<tr>
<td>Dune Sand AAC</td>
<td>3</td>
<td>1.1</td>
<td>7</td>
</tr>
<tr>
<td>Efflorescence Sand AAC</td>
<td>2</td>
<td>0.7</td>
<td>8</td>
</tr>
<tr>
<td>Coal Bottom Ash AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Natural Zeolite Additive AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Self-ignition Coal Gangue AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Incinerated Sewage Sludge Ash AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Bamboo Leaf Ash AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Concrete Sandwich Block/Waste Glass AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Halloysite Powder AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Air-cooled Slag AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Phosphorus Sand AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Coal Gangue/Iron Ore Tailings AAC</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>
Copper Tailings/ Blast Furnace Slag AAC 0 0 9
Perlite Waste/Polypropylene Fiber AAC 0 0 9

**Total number of times AAC blocks were used (T)** 270 100

Note: F denotes the Frequency of Utilization on the project, %MU denotes the Percentage Mean Utilization

### 4.3 Important drivers of the use of AAC in construction projects

Table 2 sheds light on the opinions of experts from Nigeria and SA on the drivers influencing the use of AAC blocks in construction projects based on their means (3.07 to 4.17 in Nigeria and 3.94 to 4.76 in SA). The finding shows that 24 drivers were ‘more important’ (3.5 and above) and two were ‘somewhat important’ (below 3.5) in Nigeria; while nine drivers were ‘most important’ (4.5 and above) and 17 were ‘more important’ (3.5 and above) in SA. None of the drivers were either ‘not important’ or ‘slightly important’ in both countries.

<table>
<thead>
<tr>
<th>Important Drivers</th>
<th>Nigerian Professionals</th>
<th>South African Professionals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N  MS</td>
<td>N  MS  R</td>
</tr>
<tr>
<td>Lightweight</td>
<td>95 4.17</td>
<td>1 17 4.71 2</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>96 4.16</td>
<td>2 17 4.71 2</td>
</tr>
<tr>
<td>Ecologically better than other conventional walling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>materials</td>
<td>93 3.98</td>
<td>3 17 4.41 14</td>
</tr>
<tr>
<td>Adaptability of AAC to tropical climates</td>
<td>95 3.95</td>
<td>4 17 4.35 16</td>
</tr>
<tr>
<td>Superior thermal absorption property</td>
<td>96 3.84</td>
<td>5 17 4.71 2</td>
</tr>
<tr>
<td>Excellent fire insulation</td>
<td>96 3.84</td>
<td>5 17 4.76 1</td>
</tr>
<tr>
<td>Readily adaptable to any style of architecture</td>
<td>94 3.84</td>
<td>5 17 4.59 5</td>
</tr>
<tr>
<td>Use of reduced labor in manufacture and installation</td>
<td>96 3.81</td>
<td>8 17 4.35 16</td>
</tr>
<tr>
<td>Made from abundant raw materials</td>
<td>96 3.80</td>
<td>9 17 4.18 21</td>
</tr>
<tr>
<td>Reduction in construction cost</td>
<td>96 3.80</td>
<td>9 17 4.35 16</td>
</tr>
<tr>
<td>Eco-friendly</td>
<td>97 3.78</td>
<td>11 17 4.59 5</td>
</tr>
<tr>
<td>Optimum thermal conductivity</td>
<td>94 3.73</td>
<td>12 17 4.59 5</td>
</tr>
<tr>
<td>Low maintenance cost</td>
<td>94 3.72</td>
<td>13 17 4.12 23</td>
</tr>
<tr>
<td>Fast and easy installation</td>
<td>96 3.70</td>
<td>14 17 4.53 8</td>
</tr>
</tbody>
</table>

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
5. DISCUSSION OF FINDINGS

The four most used AAC in SA discovered in this study supports the conclusions of Falade and Ikponmwosa (2008) that if the block is utilized in Nigeria, economic advantages will be boosted. Khalil (2020) opines that AAC is an alternative greener environment material highly sort for in the construction industry, stating that it is used extensively in Europe and Asia. Its usage has been gaining momentum in Egypt where AAC was used for a number of projects including but not limited to Four Seasons Nile Plaza Hotel, 57375 Hospital, International Medical Center, Cairo American College and Mars Factory (Khalil, 2020). Rathore (2018) also established 40%, 16% and 60% usage in United Kingdom, India and Germany respectively. Moreover, the important drivers found in this study also corroborate the findings of Rathi and Khandve (2015), that using eco-friendly AAC blocks instead of traditional red bricks reduces building costs by up to 20%. The adoption of AAC blocks also results in relatively lighter members by lowering the dead load of the wall on the beams, which decreases the need for materials like cement, reinforcement and sand by up to 50%. Besides, in South Africa, the study also uncovered that the most important drivers are: great fire insulation properties, lightweight, energy efficiency, outstanding thermal absorption capacity, adaptability to any architectural style, eco-friendliness and optimal thermal

<table>
<thead>
<tr>
<th>Feature</th>
<th>Score</th>
<th>Weight</th>
<th>Rank</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced dead load on structure</td>
<td>95</td>
<td>3.69</td>
<td>15</td>
<td>4.41</td>
</tr>
<tr>
<td>Good acoustic performance</td>
<td>93</td>
<td>3.68</td>
<td>16</td>
<td>4.18</td>
</tr>
<tr>
<td>Durability</td>
<td>96</td>
<td>3.68</td>
<td>16</td>
<td>4.47</td>
</tr>
<tr>
<td>Versatility</td>
<td>96</td>
<td>3.68</td>
<td>16</td>
<td>4.24</td>
</tr>
<tr>
<td>Recyclable</td>
<td>96</td>
<td>3.65</td>
<td>19</td>
<td>4.35</td>
</tr>
<tr>
<td>Reduced transfer of load on foundation</td>
<td>96</td>
<td>3.64</td>
<td>20</td>
<td>4.47</td>
</tr>
<tr>
<td>Breathable wall system</td>
<td>95</td>
<td>3.62</td>
<td>21</td>
<td>4.47</td>
</tr>
<tr>
<td>Non-toxic production process</td>
<td>96</td>
<td>3.61</td>
<td>22</td>
<td>4.53</td>
</tr>
<tr>
<td>Cost effectiveness</td>
<td>96</td>
<td>3.53</td>
<td>23</td>
<td>4.47</td>
</tr>
<tr>
<td>Moisture resistant</td>
<td>95</td>
<td>3.52</td>
<td>24</td>
<td>4.12</td>
</tr>
<tr>
<td>Resistance to pest and mold</td>
<td>96</td>
<td>3.33</td>
<td>25</td>
<td>3.94</td>
</tr>
<tr>
<td>Good appearance</td>
<td>96</td>
<td>3.07</td>
<td>26</td>
<td>4.06</td>
</tr>
</tbody>
</table>
conductivity, among others (Plena, 2018). According to Research and Market (2020), AAC is adopted on building projects in South Korea due to the benefit it offers to a building by reducing cooling and heating demands. Its widespread adoption in Canada is also due to its ability to withstand heat (Research and Market, 2020). Whereas, in the UK, it is adopted to enhance thermal and acoustic performances. It can also be seen that this supports the claims of Pandey et al. (2018) that AAC is lightweight and has a low heat conductivity since it is aerated and includes 50–60% air. The energy used in the production process does not produce any harmful byproducts or wastes, nor does it release any pollutants. AAC is workable, which reduces waste on the task, and has a higher compressive strength than typical clay bricks. In the same vein, Khalil (2020) gives credence to the energy saving ability of AAC as a property endearing to users.

6. CONCLUSIONS AND RECOMMENDATIONS

The study concludes that there are four AAC commonly used in SA, this suggests that AAC block makers that develop AAC variations other than the four leading versions would likely not thrive in business due to low patronage. Additionally, the study comes to the conclusion that although lightweight is the most important driver, the value of drivers for the adoption of AAC blocks varies for both nations, and professionals choose AAC for different reasons. Therefore, the study recommends that participants and specifiers in construction projects should make sure that deliberate efforts are taken while choosing and specifying AAC blocks for walling. This may be accomplished through increasing awareness of the benefits of AAC.

7. LIMITATIONS OF THE STUDY AND FUTURE RESEARCH

This study is perception-based and requires validation on real life projects. The properties of AAC blocks produced locally should also be determined and ascertained in a laboratory experiment.

8. REFERENCES


Olatunji Joseph Oladiran, Iruka Chijindu Anugwo and Dele Roger Simeon


ABSTRACT
Purpose of this paper
This study sought to establish nuances within SMC taxonomy in the Namibian construction industry in a bid to ensure sustainable procurement management and progressive SMC development within this setting.

Design/methodology/approach
The study adopted a cross-sectional survey design by administering a web-based questionnaire survey tool to gather data on firms’ annual turnover and employment levels experienced over a five-year period spanning from 2017 to 2021. The participants involved owner-managers of small and medium-sized contracting firms based in Windhoek and Oshakati town. Data were analysed using trend and cross-sectional analysis.

Findings
The study observed the existence of seven (7) classes among SMCs namely micro-small, micro-medium, small, small-medium, small-large, medium, and medium-large category. Thus, transitional and overlapping classes were observed among SMCs namely micro-small, micro-medium, small-medium, small-large and medium-large contractor. These transitional and overlapping classes are not clearly highlighted in the MSME policy of Namibia.

Research limitations/implications
The small sample size and the geographical delimitation employed precludes the study from being generalised to other settings without caution.

Practical implications
The identified nuances within SMC classification could be utilised by government, policymakers, and other relevant stakeholders to formulate and implement appropriate interventions that promote sustainable procurement management and progressive SMC development in Namibia and similar contexts.

Originality/value of paper.
There is dearth of literature on SMC taxonomy within the Namibian context. Moreover, little is known in extant literature regarding nuances that exist among SMC taxonomy, hence the current study is novel. Therefore, the study findings could assist in identifying distinct classes that exist among SMCs which would assist in formulating apt policies and interventions for enhancing sustainable procurement management and progressive SMC development in Namibia and similar contexts.

Keywords: SMC taxonomy, SMC nuances, SMC development, SMC sustainability, SMCs, Namibia
1.0. INTRODUCTION

The classification of contractors is reportedly critical in catalysing the development and sustainability of small and medium-sized contractors in most developing countries (Lello and Mtendamema, 2018; Offei, Kissi and Nani, 2019; Ogbu and Asuquo, 2019). Most African developing countries which include Ghana (Eyiah, 2003; Eyiah and Cook, 2010), South Africa (Hove, 2016; Amoah and Bikitsha, 2021), Nigeria (Ogbu and Asuquo, 2019), Tanzania (Lello and Mtendamema, 2018) and Botswana (Kobole, 2009) have adopted contractor classification system to progressively develop their SMCs. Furthermore, advanced and emerging economies like Australia (Lou and Goulding, 2008), Japan (Reeves, 2002), Singapore (Kumaraswamy, Egmond and Rahman, 2002; Ofori, Leong and Pin, 2002) and Malaysia (Kamal and Flanagan, 2012) embraced contractor classification system since the past four decades. Considering the perceived importance of contractor classification as articulated by the cited scholars, it appears that the nature of classification fundamentally assists in developing SMCs in any country.

Therefore, the paper identifies and discusses the nuances that exist within SMC taxonomy in the Namibian context with the aim of effectively developing them. Firstly, the study addresses the question on how contractors are classified in the Namibian construction industry and secondly, whether the existing classes are comprehensive considering the dynamics in the construction industry? Thus, the paper starts by highlighting the importance of SMCs, followed by describing the methodological approach used, then presentation of results and discussion, and finally, the conclusion and recommendations.

2.0. LITERATURE REVIEW

2.1. Importance of Contractors’ Classification

Ogbu and Osuquo (2019) advance that the identification and classification of contractors facilitate sustainable procurement management and the discharge of appropriate interventions. This is corroborated by Gasa (2012) who points out that the rational distribution of public work and progressive development of SMCs are enhanced through contractors’ classification. Precisely, Gasa highlights that the grading of contractors assists clients and development agencies to establish programmes that are relevant to specific groups. These assertions are further supported by Cho, Lou and Goulding (2008) who submit that the classification of contractors helps in standardisation and information sharing. In other words, contractor classification aids in ensuring equitable distribution of work, so that contractors are awarded works which commensurate with their capacity and capability (Bikitsha and Amoah, 2021; CIDB of South Africa, 2022). By doing so, contractors would execute the work within their capability as suggested by ILO (2019). Generally, those that perform diligently would be upgraded or qualify to compete for bigger projects as alluded to by Bikitsha and Amoah. A good example is how Lubbe Building and Electrical Contractors in South Africa progressively developed from a small to a large contractor (Windapo, 2018).

2.2. Contractor Classification in Developing, Transitional and Developed Countries

To demonstrate how different countries classify their contractors, the study presents a snapshot from the context of South Africa, Ghana, Singapore and Australia. While the grading levels often differ with countries, the criteria employed in classifying contractors are relatively the same. Commonly used measures include annual income, number of employees, physical assets like storage space, offices, plant and equipment, then technical and managerial competencies (Lello and Mtendamema, 2018; Diabate et al., 2019; Ogbu and Asuquo, 2019).

2.2.1. South African Context

South Africa is one of the developing countries that has made significant progress in developing its
construction industry. One of the strategic moves South Africa made relates to the establishment of the Construction Industry Development Board (CIDB) in 2000 (Gasa, 2012). Accordingly, CIDB in South Africa transformed the construction industry by grading contractors into 9 grades, with grades 1 and 2 being entry levels, while grade 9 is for large contractors (Bikitsha and Amoah, 2021; CIDB South Africa, 2022). According to CIDB of South Africa (2022), grades 2 to 4 contractors participate at local level public tenders, while grades 5 to 6 execute government capital projects from local to regional level. Thwala and Mofokeng (2012) highlight that CIDB of South Africa registers contractors, maintains their data base, monitors and evaluates their operations, as well as formulating and implementing necessary interventions like training or mentorship programmes, workshops, or advisory services. Critically, contractors that underperform or breach the operational code of conduct would either stagnate, downgrade or deregister and barred from participating in public tenders for a specific period. For instance, Mofokeng and Thwala who assessed mentorship programmes in the Free State Province of South Africa, reveal that 3197 contractors were deregistered by CIDB in 2012 for varied offences. Hence, the stringent measures by CIDB invariably instil discipline and a sense of responsibility in SMCs.

2.2.2. Ghanaian Context

Ghanaian contractors can be classified by ministries like the Ministry of Water Resources (MWR), Ministry of Works and Housing (MOWH) and Ministry of Roads and Transport (MRT) (Eyiah and Cook, 2003; Offei, Kissi and Nani, 2019). As outlined by Offei et al. (2019), the MWR and MOWH categorises contractors into two major trades namely building contractors and civil engineering contractors. The building contractors are further classified as D1, D2, D3 and D4 while civil engineering contractors are classified as K1, K2, K3 and K4 as presented by Eyiah and Cook. As such, large contractors are found in D1K1 classes while SMCs occupy D2K2, D3K3 and D4K4 classes.

However, MRT uses a different coding system, which firstly classifies contractors as A, B, C and S (Eyiah and Cook, 2003). Thus, class A is for large contractors, whereas class S is for small contractors. The classification, as explained by Eyiah and Cook, is based on personnel, technical and managerial competencies, and physical assets. On the other hand, MRT uses financial income to grade contractors using code 1, 2, 3 and 4, where 1 is for high income earners and 4 being low-income earners. Based on MRT, a single contractor has a combination of classes as shown in Table 1. Hence, a contractor could be ranked high, technically, and on the other hand, ranked low, financially.

Table 1: Ghana MRT Contractor Classification

<table>
<thead>
<tr>
<th>Primary Class</th>
<th>MWR Categories</th>
<th>MOWH Categories</th>
<th>MRT Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1</td>
<td>B1</td>
<td>C1</td>
</tr>
<tr>
<td>2</td>
<td>A2</td>
<td>B2</td>
<td>C2</td>
</tr>
<tr>
<td>3</td>
<td>A3</td>
<td>B3</td>
<td>C3</td>
</tr>
<tr>
<td>4</td>
<td>A4</td>
<td>B4</td>
<td>C4</td>
</tr>
</tbody>
</table>

Source: Adapted from Eyiah and Cook (2003, p.361)

Therefore, the set up in Ghana facilitates the provision of appropriate interventions and the tracking of progressive growth of contractors.

2.2.3. Singaporean Context

Singapore is among the best performing economies in Asia that registered remarkable progress in the
development of SMCs (Ofori and Lean, 2001). The Building and Construction Authority (BCA) in Singapore is responsible for registering contractors and monitoring public tenders in the country (Choen, Lou and Goulding, 2008). BCA classifies contractors in seven (7) distinct categories namely A1, A2, B1, B2, C1, C2 and C3 (Teo and Feng, 2011, pp.84-85). Basically, large general contractors occupy grades A1 and A2, while small general contractors are found in grade B1 and B2. As noted by Teo and Feng, classes C1, C2 and C3 are for small contractors that are usually subcontracted by general contractors. Contractor grading criteria include financial capital (Kumaraswamy, Rahman, Ling and Phng, 2005, p. 1067). Table 2 shows the financial capital limit and tender ceiling for each class.

<table>
<thead>
<tr>
<th>Contractor Grade</th>
<th>A1</th>
<th>A2</th>
<th>B1</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Capital Limit</td>
<td>Minimum 15 million paid up capital</td>
<td>Minimum 6.5 million paid up capital</td>
<td>Minimum 3 million paid up capital</td>
<td>Minimum 1 million paid up capital</td>
</tr>
<tr>
<td>Tender Ceiling</td>
<td>Unlimited tendering limit</td>
<td>65 million tendering limit</td>
<td>30 million tendering limit</td>
<td>10 million tendering limit</td>
</tr>
</tbody>
</table>

Source: Adapted from Kumaraswamy (2005, p.1067)

The indicated tender ceilings help in allocating tenders according to the contracting capacity of the contractor (ILO, 2019; Bikutsha and Amoah, 2021). Besides contractor grading, BCA categories work into Workheads. Choen, Lou and Goulding (2008) describe these workheads as including construction workheads comprising general buildings (CW1) and civil engineering (CW2), mechanical and electrical workheads (ME), supply workheads (SI), and maintenance workheads (MW). These categories promote specialisation which improves operational efficiency and competitiveness (Lello and Mtendamema, 2018). This culminates in the growth and sustainability of the firm. Thus, considering the contractor classification parameters used, Singaporean SMCs are fairly developed.

2.2.4. Australian Context

The classification of SMCs in Australia is done by Home Building Services (HBS) (Choen, Lou and Goulding, 2008). As pointed out by Choen et al., HBS sets standards and monitors compliance by builders and tradespersons. Licenses are given for each work trade in accordance with one’s expertise like bricklaying, stonemasonry, plumbing, plastering, painting, tiling, glazing, electrical works, and mechanical works. Notably, Choen et al. stated that there are no financial limits and categorisation imposed in Australia.

3.0. METHODOLOGY

The study adopted a cross-sectional survey design and census approach to collect data from forty (40) SMCs which are affiliated to the Construction Industry Federation (CIF) of Namibia and domiciled in the city of Windhoek and Oshakati town. The 40 SMCs constituted the accessible population, which is approximately 57% of the total SMCs under the membership of CIF within Windhoek and Oshakati. The study administered a web based structured questionnaire survey tool to owner-managers of the selected firms to gather data on firms’ annual turnover and employment levels experienced over a 5-year period spanning from 2017 to 2021 in a bid to establish nuances that exist among SMC categories based on the mentioned two parameters commonly used to classify contractors. Windhoek is the commercial centre and capital of Namibia, thus over 80% of the
SMCs are headquartered in this city. On the other hand, Oshakati town is a fast-growing town in Northern Namibia. The collected data were analysed using trend and cross-sectional analysis. Trend analysis was based on the firm’s annual turnover and employment levels over a 5-year period spanning from 2017 to 2021, while cross-sectional analysis was employed to compare trends between employment levels and annual turnover over the 5-year period since these two parameters are used to define SMCs within the Namibian context.

4.0. RESULTS AND DISCUSSION
Of the 40 administered questionnaires, 22 were returned, thus representing a 55% response rate which is acceptable. The returned questionnaires were checked for completeness and found to be acceptable. Of the 22 responses, 15 (68%) and 7 (32%) were based in Windhoek and Oshakati, respectively. The data are presented and analysed in succeeding sections.

4.1. Respondents’ Demographic Data

![Figure 1: Level of Education](image)

As indicated on Figure 1, it was observed that 8(36%) and 5(23%) respondents hold bachelor’s degrees and grade 12 certificates respectively, while the remaining 41% either possess a short learning course, certificate, diploma, honours or master’s degree.

4.2. Firm’s Annual Turnover
According to the National Policy on Micro, Small and Medium Enterprises in Namibia (2016), small enterprises are firms whose annual turnover ranges from N$ 300 001 to N$ 3 000 000, while medium enterprises...
are firms with an annual turnover spanning from N$3 000 001 to N$ 10 000. By extension, large enterprises are therefore firms whose annual turnover exceeds N$10 000 000. Figure 2 shows the results on firms' annual turnover obtained as from 2017 to 2021.

![Annual Income](image)

**Figure 2**: Firms’ Annual Turnover

The results presented in Figure 2 show the inconsistencies in the growth and possible classification of SMCs as measured by annual turnover over the assessed 5-year period. For instance, in 2017, 12 (55%) of the contracting firms indicated an annual turnover of less than N$ 3 million, hence classified as small contractors. On the other hand, 5 (23%) were falling under medium contractors since they had an annual turnover of between 3 million to 10 million Namibia dollars, while the other 5 (23%) fell under large contractors since they had an annual turnover of over 10 million Namibia dollars. However, between 2017 and 2018, the findings show a sharp increase of medium-sized contractors while a sharp decline was witnessed among small contractors during the same period. Therefore, the results demonstrated that the classification of most contractors oscillated during the 5-year period based on annual turnover.

4.3. Firm' Employment Levels

Besides annual turnover, employment levels are also commonly used to classify contractors. Figure 3 indicates results obtained from the study.
The study observed rapid changes in firms’ employment levels over the 5-year period. For instance, in 2017, 8 (36%) of the firms employed less than 11 personnel, thus classified as micro-sized contractors, while 9 (41%) of the firms employed between 11 to 30 employees, thus classified as small-sized contractors. On the other hand, the study found that firms that could be viewed as medium-sized in 2017 were 3 (14%). However, in 2018, the results indicated that small contractors increased from 9 (41%) in 2017 to 12 (55%) in 2018. During the same period, firms employing less than 11 personnel sharply declined from 8 (36%) to 4 (18%), which could be an indication that some micro-sized contractors grew to small contractors between 2017 and 2018. These dynamics were observable throughout the 5-year period.

While it is easier to classify a contractor based on a single parameter like annual turnover or employment level, it has been observed to be challenging when using a combination of the two parameters as demonstrated in Table 3.

4.4. Cross-Sectional Analysis

A cross-sectional analysis of annual turnover and employment Levels is presented in Table 3, with respondents being labelled P1 to P22.
<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Turnover</th>
<th>No. of Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;N$ 3 000 000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N$ 3 000 001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;N$ 10 000 000</td>
<td></td>
</tr>
<tr>
<td>&lt; 11</td>
<td>11 to 30</td>
<td>31 to 100</td>
</tr>
<tr>
<td>2017</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2018</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2019</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2020</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2021</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Table 3:** Cross-Sectional Analysis of Annual Turnover and Employment Levels

<table>
<thead>
<tr>
<th>Year</th>
<th>P1 Rating</th>
<th>P2 Rating</th>
<th>P3 Rating</th>
<th>P4 Rating</th>
<th>P5 Rating</th>
<th>P6 Rating</th>
<th>P7 Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>P8 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P9 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P10 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P11 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P12 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P13 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P14 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P15 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P16 Rating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
From the results presented in Table 3, P1 had consistent annual turnover of above ten million Namibia dollars (N$10 000 000) and the number of employees that exceeded one hundred in 2017 and 2018. This made P1 to be viewed as a large contractor based on both parameters during the mentioned 2 years. However, in 2019, P1’s annual turnover dropped from above 10 million Namibia dollars as indicated in previous years to medium-sized category while employment levels remained in the large category (above 100 employees). Consequently, P1 exhibited characteristics of both medium-sized and large-sized contractor in 2019, thereby making it a medium-large sized contractor. On the other hand, P2 showed that the firm consistently maintained employees of between 11 to 30 as from 2017 to 2020, thereby making it a small contractor. However, P2 had inconsistencies.

### Table 3: Contractor Performance Rating

<table>
<thead>
<tr>
<th>Year</th>
<th>P17 Rating</th>
<th>P18 Rating</th>
<th>P19 Rating</th>
<th>P20 Rating</th>
<th>P21 Rating</th>
<th>P22 Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2018</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2019</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2020</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2021</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Source: Researcher’s own construct (2023)
in annual turnover during those 4 years (2017 to 2020). For instance, in 2017, P2 had an annual turnover of above 10 million Namibia dollars, hence falling in a large-sized category. Thus, using both employment level and annual turnover of 2017, P2 would be viewed as small-large contractor, since the firm exhibited the characteristics of both a small contractor and a large-sized contractor. Then using both parameters in 2018, P2 displayed the characteristics of a small contractor in terms of annual turnover and employment levels. However, in 2019, P2’s annual turnover increased to a medium-sized category, that is being above 3 million but not exceeding 10 million Namibia dollars, while employment level remained within the small category. As such, in 2019, P2 was viewed as a small-medium sized contractor. These nuances were visible among the other 20 respondents during 2017 to 2021. Therefore, based on the cross-sectional analysis, the study observed that, in addition to small and medium-sized categories, there are transitional classes that exist among SMCs which include micro-small, small-medium, and medium-large contractors. Furthermore, overlaps were observed among SMCs namely micro-medium, and small-large sized contractors. Thus, the analysis resulted in seven (7) classes namely micro-small, micro-medium, small, small-medium, small-large, medium, and medium-large contractor as indicated Table 3.

Table 4: Nuances in SMC Taxonomy

<table>
<thead>
<tr>
<th>Category</th>
<th>Contractor Classification Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro-Small</td>
<td>Employment level of less than 10 employees and Annual Turnover ranging from N$300 001 to N$3 000 000 OR Annual Turnover of upto N$300 000 and Employment level of 11 to 30 employees</td>
</tr>
<tr>
<td>Micro-Medium</td>
<td>Employment level of less than 10 employees and Annual Turnover ranging from N$3000 001 to N$10 000 000 OR Annual Turnover of upto N$300 000 and Employment level of 31 to 100 employees</td>
</tr>
<tr>
<td>Small</td>
<td>Employment level of 11 to 30 employees and Annual Turnover ranging from N$300 001 to N$3 000 000</td>
</tr>
<tr>
<td>Small-Medium</td>
<td>Employment level of 11 to 30 employees and Annual Turnover ranging from N$3000 001 to N$10 000 000 OR Annual Turnover ranging from N$300 001 to N$3 000 000 and Employment level of 31 to 100 employees</td>
</tr>
<tr>
<td>Small-Large</td>
<td>Employment level of 11 to 30 employees and Annual Turnover exceeding N$10 000 000 OR Annual Turnover ranging from N$300 001 to N$3 000 000 and Employment level exceeding 100 employees</td>
</tr>
<tr>
<td>Medium</td>
<td>Employment level of 31 to 100 employees and Annual Turnover ranging from N$3000 001 to N$10 000 000</td>
</tr>
</tbody>
</table>
The annual turnover and number of employees in a firm are widely employed by most countries to classify contractors (Arthur-aidoo, Martin, Aigbavboa and Thwala, 2018; Lello and Mtendamema, 2018; Diabate et al., 2019). In a study in Ghana, Eyiah and Cook (2003) confirm that categorising a contractor based on a single parameter does not reflect the holistic status of a contractor. Hence, the use of both employment levels and annual turnover is reportedly critical in providing financial and technical reflection of a firm’s capacity and capability. In further supporting the findings, Ogbu and Asuquo (2019) who observed in the Nigerian context advance that the correct classification of contractors is critical to effectively manage the procurement process, as well as providing the appropriate interventions to catalyse indigenous contractor development. However, the findings of the study demonstrate that the grading of SMCs is more complex than the way it is presented in most policy documents like the Micro, Small and Medium Enterprise Policy of Namibia (2016). The overlaps observed in the current study are not clearly highlighted in extant literature. CIDB of South Africa (2022) and CIDB of Malaysia (2019) classified contractors in nine (9) and seven (7) classes or grades respectively. However, their classifications do not highlight the nuances observed in the current study, hence the current results unpack critical information that could enhance a holistic classification of contractors for effective SMC development and subsequent sustainable socio-economic development.

5.0. CONCLUSIONS AND RECOMMENDATIONS

This study sought to establish the nuances that exist within SMC taxonomy in the Namibian context. Based on the findings, the study concluded that there are seven (7) classes within SMC category namely micro-small, micro-medium, small, small-medium, small-large, medium, and medium-large contractor. Thus, overlaps and transitional classes were observed to characterise SMCs. These classes were found to be critical to effectively develop SMC through rational procurement and provision of appropriate interventions. Additionally, the study found that the classification of contractors should be done using a combination of parameters such as employment levels and annual turnover in a bid to identify transitional classes and overlapping classes that exist within the SMC category. The classification criteria were observed to be holistic and informative compared to a single parameter which often distorts reality regarding the capability and capacity of a contractor to successfully execute projects. Hence, the study concluded that aggregated annual turnover and employment levels obtained over several years provides better data that could assist in classifying a contractor since the parameters like annual turnover and employment levels often vary with market conditions.

Consequently, the study recommends that policymakers, government, and other stakeholders adopt the envisaged classification criteria and the identified classes to develop appropriate interventions that promote sustainable procurement management and progressive SMC development. Thus, the results of the study have potential to inform SMC development policy within the Namibian context and similar settings. However, the low sample size and geographical delimitation precludes the findings from being generalised without caution.

6.0. REFERENCES

Amoah, C. and Bikitsha, L. (2021). ‘Emerging contractor’ s management and planning skills to overcome


WikiHouse: A Sustainable Alternative to the South African Housing Problem?

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ABSTRACT

Purpose of this paper
This scoping review aims to investigate the potential of the WikiHouse concept as a sustainable and innovative solution to the South African housing problem.

Design/methodology/approach
The study utilises a scoping review methodology to examine relevant literature on the WikiHouse concept and South Africa’s housing challenges, analysing and synthesising the findings to answer the relevant research questions.

Findings
The study finds that the WikiHouse system outperforms traditional housing solutions and better fits the objectives of the South African housing programme and the DHS.

What is original/value of paper
This study contributes to the existing literature by exploring the application of the WikiHouse concept in the specific context of South African housing. The findings demonstrate the potential of WikiHouse as an innovative and environmentally sustainable solution that aligns with the objectives outlined by the South African government. The study provides valuable insights and recommendations for further research and implementation of the WikiHouse concept in addressing the housing challenges in South Africa.

Keywords: WikiHouse, Sustainability, South Africa, Housing problem, Open-source construction
1. INTRODUCTION

One of the major ongoing challenges South Africa faces today is rapid urbanisation due to an ever-increasing demand for affordable housing opportunities (Department of Human Settlements (South Africa), 2020). This problem is exacerbated by people experiencing poverty, who migrate to urban areas for employment, where they eventually create and settle in ever-expanding but unsustainable informal settlements.

The “right of access to adequate housing” is considered a fundamental human need and is therefore enshrined within the Constitution of South Africa (The Republic of South Africa, 1996). In 1994, the newly elected administration issued the Housing White Paper, outlining a new national housing vision, strategy, and policy, that was intended to address the pressing housing crisis (Department of Housing (South Africa), 1994). Today, the Department of Human Settlements (DHS) still seeks to “facilitate the creation of sustainable human settlements and improved quality of household life” as part of its constitutional mandate (Department of Human Settlements (South Africa), 2020). The DHS has implemented various housing mechanisms to provide safe and secure homes to low-income households.

Unfortunately, the national housing policy and accompanying housing programmes, such as the Reconstruction and Development Programme (RDP), have received widespread criticism within the literature, casting a cloud over the effectiveness of these initiatives. Early into the tenure of the new administration, Huchzermeyer (2001) already questioned the RDP’s housing finance systems and the notion of giving families dwellings on separate plots, arguing that doing so results in poor spatial integration and urban development.

Others criticise the unfavourable locality of the RDP houses that often lead to increased travel distance for inhabitants and poor spatial planning, creating unsafe environments in the form of slums due to social issues (Charlton, 2018; Gilbert, 2004). Furthermore, the housing quality is often left wanting (Amoah et al., 2022). The implementation mechanisms have also been said to have serious flaws in poor project management, corruption and lack of governmental support (Amoah et al., 2020b; Scheba and Turok, 2021; Turok et al., 2022). Compared to other countries’ housing programmes, South Africa’s housing programme has been criticised for being too narrowly focused by only providing housing to a specific income band (Aduwo et al., 2022). Finally, on a policy and strategic level, the housing initiative has been criticised for having contradictory agendas and goals, further hampering its effectiveness (Charlton, 2009; Watt and Smets, 2017).

This paper seeks to explore the sustainability aspect of South African government-housing solutions. The current housing initiatives have received the same level of criticism regarding environmental sustainability. As mentioned earlier, government housing negatively impacts the environment due to poor locality, which increases travel distance (usually via bus or taxi minibus) and increases carbon emissions (Culwick and Patel, 2020). Furthermore, procurement and construction also fail to address the potential for climate change mitigation (Vawda and Hugo, 2022). Amoah (2023) found a complete disregard for environmental issues within the government’s current housing policy, even though it is clearly mentioned within the vision and goals of the DHS. Considering the barrage of criticisms and evidence directed at the South African government’s approaches to the housing problem, it is evident that there is an urgent need to re-evaluate the existing efforts and develop innovative and environmentally sustainable alternatives that can make a clear and meaningful impact.

In recent years, advancements in digital manufacturing technologies have paved the way for progress in open construction. These technologies, including computer numerically controlled (CNC) machines, laser cutters, and three-dimensional (3D) printing, have revolutionised the possibilities for additive and subtractive manufacturing in the construction industry. Concurrently, commons-based peer production (CBPP) has emerged as an innovative approach to value creation within a globally connected information society (Priavolou, 2018). CBPP involves collaborative communities utilising technological capabilities to produce and openly share...
solutions, empowering others to use and expand upon shared resources (Kostakis et al., 2018). Within this context, the Design Global, Manufacture Local (DGML) model has gained recognition as a form of CBPP emphasising sustainability across economic, environmental, and socio-political dimensions. The DGML model leverages the convergence of digital commons and local manufacturing technologies to enable cooperative design and production. Distributed maker spaces equipped with simple tools and desktop manufacturing technologies provide the platform for local co-creation with an emphasis on sustainability.

In DGML and CBPP, the WikiHouse building system stands out as an exemplar that embodies open collaboration and localised manufacturing principles. WikiHouse is an open-source platform for designing and constructing homes, utilising digital technologies and open design principles (Chan, 2020; Priavolou, 2018; Priavolou and Niaros, 2019). The principles upon which the WikiHouse concept is based make it worth considering when exploring sustainable alternatives to South Africa’s housing problem.

This study aims to perform a scoping review on open construction concepts, with a particular focus on the WikiHouse concept and its applicability to South Africa as a sustainable housing solution. Research on the WikiHouse concept as applied to the housing problem is still relatively new. A scoping review enables the researcher to examine these broad areas of research where a lot of uncertainty still reigns. Furthermore, a scoping review identifies gaps in the research and clarifies key concepts. It informs the researcher of evidence and common practice within a specific field of research (Peters et al., 2015).

2. METHODOLOGY

The Arksey and O’Malley (2005) framework for scoping reviews was chosen for this review. According to the framework, the following research questions were posed:

1. What are the typical requirements of government housing in South Africa?
2. What are the expected benefits of the WikiHouse concept?
3. What are the expected challenges with the WikiHouse concept?

The scoping review was performed by reviewing literature from the Scopus and Web of Science databases. These databases were chosen based on their relevance to the field of study and the reliable nature of their peer-reviewed literature. Furthermore, the review is limited to peer-reviewed English publications from 2000 onward. The type of literature used for the review was contextualised so that only knowledge relevant to the study was considered.

Throughout this review, no literature was found to exist on applying the WikiHouse concept to the South African housing problem, which highlights the gap in the research this study aims to address. However, a few pieces of literature exist on the WikiHouse applied to housing in general. Many publications on government housing applied to South Africa also exist. This leads to a convenient and effective scoping review strategy: studying the literature on the WikiHouse concept and its housing application, as well as literature on South Africa and its governmental housing strategy, with the end goal of taking what is relevant from both domains and creating an amalgamation of the relevant research. The result was synthesised knowledge of the WikiHouse concept applied to the South African housing problem. Using this search strategy fills the identified gap in the literature.

Table 2.1 depicts the search strategy that was followed for this scoping review. The keywords used were "WikiHouse", "Social Housing", and "South Africa" in different combinations. A screening process was then undertaken by adding exclusion and inclusion criteria and filtering the literature to find relevant results. Out of 78 studies, 31 were identified and analysed to answer the posed research questions. Twenty-three of these studies were specifically relevant to the South African housing context, while eight studies pertained to research on the WikiHouse concept and its place within the construction and housing field of research. Finally, the
Table 2.1: Scoping review search strategy.

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<th>Search Strategy</th>
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3. RESULTS
3.1. What are the typical requirements of government housing in South Africa?

3.1.1. Current types of government-housing

Before addressing this question, it is imperative to understand the diverse mechanisms the state employs to facilitate housing provision in South Africa. The primary and widely recognised form of state-provided housing is known as RDP housing. The government constructs various types of RDP houses, which are subsequently assigned to households with incomes below a specified threshold. This is achieved through the utilisation of a "subsidy housing for ownership" framework, wherein beneficiaries receive a one-time grant encompassing the land, house, and basic amenities (Landman and Napier, 2010). Typically, a solitary RDP house occupies an area of approximately 30-40 m² and is developed on a 250 m² plot of land. Nevertheless, there is a degree of adaptability in implementing the subsidy housing for ownership approach. For instance, some developers have explored alternative designs, such as constructing units with smaller land plots to enable densification.

Another form of government housing comprises medium-to-high-density housing units owned by the state and typically rented to low-income households. These units are also occasionally referred to as social or public housing. The number of housing units falling under this classification is much less than that of state-subsidised housing. Gap housing represents another variant of state-provided housing that endeavours to bridge the gap in the housing market for the upper segment of low-income households that fall short of the eligibility criteria for subsidy housing. Within the context of this analysis, gap housing will be regarded as a type of...
of social housing since housing institutions frequently employ subsidies to co-finance the development of both social and gap-housing units. Lastly, the People's Housing Process (PHP) stands as the final archetype of government housing, wherein the government provides subsidies and facilitates collective efforts among communities to construct their own houses. This approach is commonly known as self-help housing.

Based on the different types of governmental housing present in South Africa, an examination of the requisites for such housing can now be facilitated. The inquiry into the typical requirements of government housing in South Africa may be approached from multiple perspectives. Firstly, the viability of a governmental housing unit is directly contingent upon South African legislation, encompassing building regulations and acts pertaining specifically to social and governmental housing. Secondly, the housing unit must align with the vision and objectives outlined by the Department of Human Settlements and comply with the stipulations set forth in the housing policy and strategy. Lastly, the housing unit must meet the expectations of its prospective inhabitants.

3.1.2. Legal and regulatory requirements

Section 20 of the Social Housing Act (Act No. 16 of 2008) stipulates that housing should comply with municipal requirements and the minimum standards of the Housing Code and Building Regulations concerning size and quality of finish (Department of the Prime Minister, 1977). These units must also meet the standards enforced by the South African Bureau of Standards (The Presidency of South Africa, 2008). That means the units must be safe and comfortable regarding their physical properties, including material strength, insulation, space and dimensions etc. Furthermore, the design of the units must adhere to municipal by-laws and land use rights while taking into consideration the possibility of future upgrades to the unit. When specifically referring to social housing (as opposed to housing from the RDP), only medium-to-high-density units are eligible. Apart from the unit's design criteria, it also needs to be financially viable, good project management needs to be practised throughout its development, and good market research needs to be done before and during project implementation to respond to actual demand. Finally, a plan needs to be set for the management and maintenance of the housing unit if it is the government's responsibility after the development has finished (as is the case with social housing for rent).

3.1.3. Strategic and policy-related requirements

The Revised Strategic Plan 2020-2025 lays out the general housing vision, mission and strategic focus of the DHS, detailing how it wishes to meet the housing demand and address the South African housing problem (Department of Human Settlements (South Africa), 2020). It can be concluded that governmental housing must be built upon the values of the DHS. In other words, the ideal government-provided house is environmentally and economically sustainable, serving as an innovative housing solution that offers low-income households the choice of quality and affordable options. The house must be delivered fairly and equitably while holding those involved in its development to a high standard of accountability.

We can build upon this by ensuring that we meet the objectives and outcomes of the South African housing programme (Department of Housing (South Africa), 1994). Charlton (2009) summarises these objectives as follows. Firstly, the focus is placed on actual housing delivery. This means that the housing mechanism must be able to practically deliver many housing units within an acceptable amount of time. Consequently, the housing unit should be simple enough in design to construct it quickly enough while being built out of easily accessible and affordable materials. There has since been a shift of focus from ‘quantity of output’ regarding governmental housing to ‘output quality’ (Tomlinson, 2006). In other words, the actual housing delivery must not come at the cost of quality, as for many state-provided housing units (Amoah et al., 2022).

Secondly, government-provided housing should contribute to the economy by actively fostering a market value for the housing products after their development. The determination of market value encompasses...
various economic factors, including locality, construction quality, and the perception of the housing unit as an economic asset capable of generating income. (Charlton, 2018; Turok et al., 2022). It has also been shown that private investment (in conjunction with governmental subsidies) is vitally important to make housing initiatives succeed (Maass, 2013; Mazhinduka et al., 2020). Thirdly, the housing market must be enabled by the housing solution.

This aspect goes hand-in-hand with the previous objective of housing contributing to the economy.

Fourthly, the housing solution should actively contribute to the alleviation of poverty. This aspect primarily hinges on policy considerations, encompassing the effectiveness of the solution's implementation and its intended beneficiaries. How this poverty alleviation is meant to transpire has sparked considerable debate, with the existing literature scrutinising the current approaches of the housing program and expressing notable criticism. As a result, this particular aspect falls beyond the scope of the present paper. Finally, government-provided housing ought to cultivate a sense of co-sovereignty, which has been extensively addressed in social housing discourse. Co-sovereignty, in its broader context, pertains to the emancipation and empowerment of citizens who, through homeownership, transcend their roles as mere residents of social housing (Gunter, 2013). Instead, they become co-sovereigns, possessing shared ownership of their neighbourhood, city, and country in which they reside. Consequently, citizens develop a heightened commitment to the welfare of their community and nation, actively striving for their improvement. Because of this, the concept of co-sovereignty often goes hand-in-hand with self-build housing and participatory development (Miles, 2013). This is particularly important for the overall vision of the South African housing programme because it contributes to developing more inclusive and collaborative communities (Lemanski, 2008).

3.1.4. Governmental-housing expectations

Amoah et al. (2020a) investigated the efficacy of social housing in South Africa, specifically by assessing the extent to which the expectations of housing beneficiaries were met. The findings of this study demonstrate significant alignment with the housing requirements discussed earlier in this section. Overall, recipients of government-provided housing express consensus in terms of their beliefs that social housing should ameliorate living conditions, create a comfortable and safe environment, ensure adequate sanitation facilities, possess dimensions suitable for accommodating typical family sizes, exhibit good quality and finishing, and be linked to good road networks to enhance everyday accessibility.

3.2. What are the expected benefits of the WikiHouse concept?

3.2.1. The WikiHouse concept

The WikiHouse concept is an open construction system developed in 2011 by two architects from Architecture 00, Alastair Parvin and Nick Ierdiaconou, who sought to explore digital fabrication and open-source technology as disruptive forces to the architectural and construction industries (Castle, 2018; Parvin, 2013). The system utilises readily available digital infrastructures like Internet connectivity and local computer numerical control (CNC) machines. Designs are crowd-sourced and freely available for download globally, which can then be used to precision-cut structural timber (like plywood) into sheets that when assembled, act as basic building blocks.

These sheets are then delivered to the building site along with their assembly instructions. The pieces from the sheets fit together through wedge and peg connections to form the chassis of the house. Following the pictorial assembly instructions makes the assembly process simple enough that someone without prior construction experience can assemble the WikiHouse. If all goes to plan, it should take a small, well-trained team about three weeks to build the chassis of a small, compact double-storey house. After that, the WikiHouse is equipped with fixtures, fittings and finishes, essentially converting the wooden structure into a home within about twelve weeks from the project start.
3.2.2. The WikiHouse’s performance

A building system such as the WikiHouse offers numerous benefits. Extensive testing conducted by the WikiHouse Foundation in collaboration with Leeds Beckett University involved comparing the performance metrics of the WikiHouse building system to that of a brick building of equivalent dimensions, specifically a typical two-storey, two-bedroom house in the United Kingdom (WikiHouse, 2023). Despite similar construction costs between the two types of structures, the WikiHouse surpassed its counterpart in all other performance measures. It demonstrated superior construction speed, thermal insulation, material reusability, and overall project carbon cost. While the brick building required 12 to 24 weeks for construction, the WikiHouse typically took only 4 to 12 weeks, owing to the subtractive manufacturing techniques employed for fabricating the building blocks. The conventional brick building exhibited a typical fabric heat loss of approximately 0.18 W/m²K. In contrast, the WikiHouse showcased a lower rate of heat loss at about 0.14 W/m²K, affecting annual power consumption for space heating. The conventional building consumed around 4200 kWh annually, whereas the WikiHouse only required approximately 2000 kWh for space heating. Furthermore, WikiHouse’s environmental and sustainability advantages stood out as the most notable benefit. Utilising materials such as plywood, the WikiHouse resulted in a net negative project carbon cost of 17 tonnes of CO₂, starkly contrasting the total project carbon cost of roughly 30 tonnes of CO₂ for the conventional brick building.

Quidel et al. (2023) conducted research substantiating many benefits. Their findings revealed an average construction time of 4.1 hours per square meter for the WikiHouse, significantly faster than the 7.3 hours per square meter typically required for traditional brick construction. Notably, this construction time was even quicker than that of prefabricated wood or steel construction, which averaged 4.5 hours per square meter. By using natural insulating materials like straw, sand, and clay, thermal losses ranged between 0.111 W/m²K and 0.162 W/m²K, depending on the specific element being measured (ceiling, floor, or walls). The researchers said these results complied with even the most stringent regulations.

Additionally, a life cycle analysis encompassing the entire construction process, from raw material extraction to waste disposal, demonstrated that the excellent thermal insulation significantly mitigated any initial carbon emissions associated with the highly processed nature of the plywood. The addition of solar panels further enhanced this reduction. Research has indicated that timber, as a construction material, can be considered one of the most environmentally friendly options due to its renewability and the carbon capture and storage capacity of trees, effectively reducing atmospheric carbon dioxide levels (Marfella and Winson-Geideman, 2021).

Finally, the quality of finish of the units for existing WikiHouse housing projects has been shown to exceed the quality of existing housing infrastructure (Priavolou, 2018).

3.2.3. The “soft” benefits

In addition to the tangible benefits demonstrated by the WikiHouse concept in terms of physical performance metrics, numerous "soft" benefits have also been highlighted in the literature. One prominent "soft" benefit discussed in scholarly works is the system’s accessibility. The WikiHouse concept embodies the essence of economist John Maynard Keynes’ insightful quote, "It is easier to ship recipes than cakes and biscuits" (Castle, 2018). By leveraging platforms like GitHub, the system enables sharing of designs and assembly instructions worldwide, empowering individuals with the necessary tools to create their desired designs (Priavolou and Niaros, 2019). Moreover, the system generates a bill of materials that facilitates local context-specific cost analyses. The global WikiHouse community also proves invaluable in generating new designs and initiating fresh projects. The construction itself is made straightforward by following the accompanying visual building instructions specific to each design, enabling informal construction teams to assemble housing units (Parvin, 2013; Priavolou, 2018).

Furthermore, the customisability of WikiHouse designs is a significant advantage. Communities can
create designs that embody their unique identity, fostering social value by establishing connections and instilling a sense of pride (Bauman and Harker, 2020). Although the WikiHouse building system exhibits standardisation, it does not sacrifice customisability, as is often the case. The system's modular nature allows for standardised building blocks that can be configured in various arrangements to create distinctive structures tailored to the project's requirements (Priavolou, 2018). This flexibility provides the WikiHouse building system with a distinct adaptability that can accommodate diverse contexts and needs.

Lastly, research has indicated that the WikiHouse concept can foster openness and conviviality by involving communities in construction (Priavolou and Niaros, 2019).

3.3. **What are the expected challenges with the WikiHouse concept?**

The WikiHouse concept presents several notable challenges that warrant careful consideration. First and foremost is its novelty, as the building system disrupts the established norms of the architectural and construction industries, challenging the existing status quo (Bauman and Harker, 2020). While this disruptive nature is not inherently negative, the concept may encounter significant resistance during its uptake and implementation due to its departure from established practices and vested interests.

Secondly, an inherent risk associated with the WikiHouse concept is its uncertainty. Despite being tested and piloted in various countries and universities, the suitability and effectiveness of the system cannot be assumed across different regional contexts and environments (Priavolou, 2018). Therefore, thorough research and analysis are necessary to ensure the seamless integration of the system into existing systems and infrastructures while accounting for regional variations.

Thirdly, when evaluating the physical performance of timber-constructed housing, such as the case with the WikiHouse building system, careful attention must be given to factors like structural integrity and fire performance. It is crucial to assess whether the building meets the requisite local construction standards and regulations regarding fire safety (Granello et al., 2022; Priavolou, 2018).

Finally, one of the advantages of open construction systems like WikiHouse is the active involvement of communities. However, the practical implementation and manifestation of this community involvement need to be thoroughly examined, taking into account the specific context and background of the systems (Priavolou, 2018). Understanding how community participation can be effectively harnessed and integrated within the WikiHouse framework necessitates a nuanced assessment that acknowledges each context's unique characteristics and dynamics.

4. **DISCUSSION**

While several peer-reviewed publications exist on the South African housing problem, with limited coverage of the WikiHouse concept applied to housing use cases, none specifically address the application of the WikiHouse concept to the South African housing context. This study aims to initiate filling the identified gap in the research. This study's findings indicate the WikiHouse concept's potential as a sustainable and innovative solution to the South African housing problem, aligning with the ideal government housing solution outlined by the DHS (Department of Human Settlements (South Africa), 2020).

Firstly, the WikiHouse concept outperforms traditional construction systems across various performance measures (Quidel et al., 2023; WikiHouse, 2023). The different housing streams of South African housing programmes, including self-help housing, RDP housing, social housing, or gap housing, all rely on conventional construction methods. Thus, it is reasonable to infer that the WikiHouse building system could surpass current housing solutions in terms of construction speed, thermal insulation, sustainability metrics such as net carbon footprint and power consumption, and quality of finish. Furthermore, with appropriate design and economies of scale, the WikiHouse may present a potentially more cost-effective option than traditional construction. At the very least, its cost could be on par with traditional methods while significantly reducing construction time. This
renders the WikiHouse environmentally and economically sustainable, offering high-quality, safe, and comfortable living spaces.

Secondly, the configurability and flexibility of the WikiHouse building system facilitate the creation of new housing designs that could comply with South Africa’s building regulations and standards, as specified in the building codes, standards, and social housing acts. This adaptability allows beneficiaries to choose from various designs that cater to their specific needs and accommodate their family sizes. Involving occupants in the design process enhances their sense of ownership and fosters openness, conviviality, and co-sovereignty within their communities (Gunter, 2013; Priavolou and Niaros, 2019). Well-designed neighbourhoods with proud residents can create a desirable housing market, thereby promoting economically viable housing solutions.

Finally, the standardised WikiHouse building system streamlines the housing delivery process. Its ease of construction can generate employment opportunities within the very neighbourhoods where the houses are built through training and employing local assembly teams. Moreover, using innovative building materials can stimulate new industries not typically involved in housing initiatives, thus contributing to economic growth.

5. RECOMMENDATIONS

The WikiHouse concept could be applied to the South African housing problem with great success, as it aligns with the objectives and expectations outlined in the vision and strategy of the DHS (Department of Human Settlements (South Africa), 2020). However, it is crucial to conduct further research focusing on structural compliance and fire safety within the specific context of South Africa.

Moreover, developing a well-defined pathway to implement the WikiHouse concept within the South African housing environment is essential. This pathway should address the challenges of implementing such an innovative yet disruptive idea. Overcoming resistance to change within the structural framework is a key consideration. Additionally, finding ways to incorporate current stakeholders and role players into this new approach to housing for people with low incomes is paramount. These questions necessitate careful analysis and resolution.

Finally, conducting a risk analysis is also recommended so that challenges to the implementational framework of the WikiHouse concept within the South African context can be navigated. By doing so, researchers can gain insights into the unique aspects of applying the WikiHouse concept within the framework of South African housing initiatives, which may differ from cases in other countries. This analysis should contribute to understanding the potential risks and identifying strategies to mitigate them effectively.

6. CONCLUSION

In conclusion, this scoping review delved into relevant literature concerning the WikiHouse concept and South Africa’s housing problem. The research questions posed were addressed through an examination of the identified literature. The findings of this study demonstrate that the WikiHouse system exhibits significant potential as an environmentally sustainable solution to the housing challenges in South Africa. The attributes and underlying philosophy of the WikiHouse system align with all the requirements stipulated by the South African government for housing initiatives. However, further research is necessary to develop an optimal implementation pathway for the WikiHouse concept in South Africa. This pathway should effectively address the obstacles to implementation by engaging stakeholders and proposing strategies to overcome resistance to change within the industry. Additionally, more research is required to ascertain the compliance of the WikiHouse system to structural and fire safety regulations within South Africa.

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ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa


ASOCSA2023 – [008]

Exploring the factors hindering the use of project management processes in delivering RDP houses in Tshwane

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ABSTRACT

Purpose
The constitution of South Africa stipulates that everyone has the right to have access to adequate housing. However, the backlog and to some extend the poorly delivered subsidized housing, commonly known as RDP (Reconstruction and Development Programme) in Tshwane South Africa, suggests the need to explore the hindrance of using project management processes.

Methodology
A qualitative research approach was used. The data was collected using semi-structured interviews, among twelve purposively sampled project man- agers tasked to deliver the RDP houses in Tshwane municipality. The data was analyzed using thematic analysis. Data saturation was achieved after the twelfth respondent.

Findings
The findings established the factors that stifles project managers from using the project management processes are: Lack of formalized project manage- ment manual, poor project management skills, lack of resources and lack of capacitated stakeholders in project management.

Limitations
The study was limited to Tshwane municipality in South Africa; hence the findings cannot be generalized.

Practical implications
This research provides empirical evidence of the causes hindering the use of project management processes. The findings inform the department to mitigate against these causes to ensure the use of the project management processes to deliver RDP houses in the city of Tshwane.

Keywords: Hindrance, Project Management Processes, Reconstruction and Development Programme, Tshwane

ASOCSA 17th Built Environment Conference: 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
South ASOCSA investigation into the difficulties facing government projects in Ghana was done by Sun et al., (2022). According to Krystal and Crowder, (2022), project management processes implementation in organizations with weak project management capabilities Partzsch (2020). In order to overcome the backlog of housing in Tshwane for its populace there is an urgent need to deliver between 18,000 and 30,000 new residential units per year Krysan and Crowder, (2022). This includes affordable, social housing, as per the housing demand survey conducted in the City of Tshwane’s central business district and the surrounding areas Justin, Turok and Andreas, (2020).

In order to overcome the current RDP housing backlog, project management processes implementation is imperative. Previous studies by Shrivastava, (2015) and Kenneth, (2014) established that project management processes implementation will improve project delivery. However, the process of project management implementation, involving the successful delivery of projects in organizations, presents an ongoing challenge to project managers.

It can therefore be inferred that the process of implementing project management is complicated, because it frequently requires juggling multiple human, financial, and technical factors Okeyo, (2011) to ensure its success. On the other hand, the implementation of project management processes is preceded by a clear project plan intended to serve as a roadmap. Nevertheless, Aiyetan and Dass, (2021) argued that inadequate project management, specifically related to planning and design, poor risk management, and stakeholders’ engagement during planning, design, and implementation phases, contribute to the failed use of the project management process in the South African construction industry.

Further, as the project progresses variations could be experienced. According to Ngonda and Jowah (2020) this is caused by the absence of an agreement between the top management’s set goals and those independently set by lower levels of managerial personnel. This could further hinder the implementation of project management processes.

From the current literature there is a paucity of studies that have focused on the challenges hindering the implementation of project management processes for RDP projects in South Africa. This is coupled with the lack of consensus of the challenges preventing the project management implementation. In line with this gap and the problem this paper aims to identify the challenges hindering the implementation of project management processes to enhance the management of RDP housing projects in Tshwane. The rest of this paper present the literature review, research methodology, discussion of findings, conclusions, recommendations and future research.

Literature review
Factors that hinder the implementation of project management processes

The project management processes implementation, according to Yap et al., (2022), will determine whether the project succeeds or fails. Numerous public and private organizations have used project management processes to address their problems, manage their limited resources, and accomplish crucial project goals Yap et al., (2022). In spite of their accomplishment, the main reasons for project schedule and cost overruns, failure to fulfill specifications, and stakeholder expectations have been linked to the public sector’s inadequate institutional and financial frameworks McDermot (2022) and Abbasi (2022). Furthermore, most projects in underdeveloped nations are implemented in organizations with weak project management capabilities Partzsch (2020). In addition, corruption has complicated project management in those nations Yap et al. (2022). An investigation into the difficulties facing government projects in Ghana was done by Sun et al., (2022). According to Asok et al., (2022), the corruption in projects in Ghana was attributed to the huge cost overruns, delays in project delivery, and the lack of accountability.

In the dawn of democracy in 1994 the housing provision was launched under the negotiated housing policy. The mandate of the housing provision was and is still to ensure that South African citizens and those who live in it have adequate and decent housing. However, in the Gauteng province, according to the Parliamentary Monitoring Group, (2020) the Department of Human Settlements, cannot cater for the 1.2 million people who are seeking housing. In the City of Tshwane alone there is an astounding backlog of 220 000 RDP houses, which dates as far back as 1998 Parliamentary Monitoring Group, (2020). In the City of Tshwane in 1998 Parliamentary Monitoring Group, (2020) an urgent need to deliver between 18,000 and 30,000 new residential units per year Krysan and Crowder, (2022). This includes affordable, social housing, as per the housing demand survey conducted in the City of Tshwane’s central business district and the surrounding areas Justin, Turok and Andreas, (2020).
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to re-search results, poor project management process implementation is primarily caused by a number of factors, including inflation, project complexity, in-accurate material estimates, insufficient specification, inaccurate site information, poor contract management, and a host of other issues.

Possibly on the rise, is corrupt behaviour that has stymied the use of project management processes in Nigeria’s infrastructure projects Ebekozien, (2020). Also in China, corruption in the construction sector is a significant issue that affects how the project management process is implemented Yu et al., (2019). It can further be inferred that in the South Africa construction industry, inadequate project management, specifically related to planning and design, poor risk management, and stakeholders’ engagement during planning, design, and implementation phases, contribute to the failed use of the project management process Aiyetan and Dass, (2021).

Partzsch (2020), suggested that poor support infrastructures, low levels of technology, low capacity of implementing institutions, unreliable communication, poor and protracted documentation, high turnover of leadership and workmen, low levels of accountability and transparency, and long and tedious formal decision-making procedures are typical conditions in developing countries such as Angola, Nigeria, Kenya and South Africa that complicate the implementation of project management processes.

Azozama (2016) investigated how widely project managers in the built environment of South Africa applied project management processes in construction projects. The author established that while some project managers in the construction industry do partially implement the project management processes. The results show that the structurally constrained application of project management processes is one of the primary reasons why delays and cost overruns are so common in South Africa’s built environment. Bhuiyan (2015) looked at how the application of project management processes affected Bangladesh’s building sector. While some of the donor-funded pro-jects were administered using the project management processes, the dis-covered that most projects were not in conformity with the application of these project management processes. The findings indicated that many of the organizations were unfamiliar with some of the project management processes.

The effects of using project management processes in the Iraqi construction industry are examined by Al-Zwainy et al. (2016). They discovered that the senior management lacks commitment and interest in the project management processes. The effects of incorporating project management pro-cesses into the pre-construction phases of real estate developments in Saudi Arabia was examined by Al-Samadoni et al. (2016). According to the study’s findings, there are some shortcomings in the way project management pro-cesses are used in real estate projects to oversee the pre-construction phase. As a result, new formulations and procedures are required to ensure that there is a high level of application so that it can keep up with its counter-parts in developed nations.

From the literature reviewed there is paucity of research to determine the challenges stifling the implementation of project management processes for RDPs in South Africa. Furthermore, the lack of consensus of these challenges is evinced.

Research methodology

Research philosophy derives how knowledge is created in different fields of study Saunders, Lewis and Thornhill, (2019). The philosophical stance that enhances knowledge development are positivism, critical realism, interpretivism, pragmatism and postmodernism. These philosophical stances are guided by three research assumptions i.e., ontology, epistemology, and axiology Saunders, et al. (2019). Ontology is the presumptions that researchers hold, that these believes are reasonable or accurate Scotland, (2012). Whereas the method by which we discover something, such as reality or a fact, is known as epistemology Kivunja and Kuyini, (2017). On the other hand, axiology ensures that the ethical issues that must be taken into account when writing a research report are adhered too. This includes the values required in research Finnis, (2011).
Interpretivism philosophy was adopted for this study. This philosophy ensures that the views of interpretivists, are based on lived experiences and how they are interpreted within certain cultural and historical contexts Arokiasamy, Kwaider and Balaraman (2019), the need for the interpretivist researcher to engage with the research participants is therefore highly regarded Chowdhury, (2014).

In support of the type of research philosophy adopted in any research study, Saunders, et al., (2019) identified three approaches to the development of theory i.e., deduction, induction, and abduction. Induction was the method used for this investigation to enhance theory. In developing theory, the type of research strategy adopted is imperative. The strategy would will be used in a sample of respondents to learn more about their experiences.

This study used semi-structured interview as strategy to determine the objective of this study. The rationale of using this interview method was to ensure an appropriate guide throughout the interviews. It also provides the interviewer with the capacity to probe participants for extra details Cambre, (2023). The interview questions were constructed in English. All interviews were held virtually using Microsoft Teams. The participants’ response was recorded with the Microsoft teams (audio recording). In addition, Microsoft teams’ transcript aided in capturing the literal response from participants.

The target population of the study were project managers from the Department of Human Settlement, Water and Sanitation in Tshwane. The sampling strategy adopted for the study was non-probability sampling due to the fact that non-probability sampling applies to qualitative research Cambre, (2023). The researcher made use of purposive sample as it is a sampling practice in which investigators depend upon their autonomous discernment when selecting participants appropriate to engage in the study Cambre, (2023). To obtain data saturation in qualitative investigations, it is formerly suggested that a minimum sample size of 12 be used (Clarke & Braun, 2013; Andrew, Fugard & Potts, 2014; Namey et al., 2020). Therefore, a sample of twelve project managers from the Department of Human Settlement, Water and Sanitation was considered adequate to achieve the valid and reliable data leading to data saturation.

The data was recorded during the interviews and was transcribed in the Microsoft Teams automatically. The transcribed data was then analyzed using thematic analysis. To achieve validity the researcher went over the recordings and affirmed that the recordings were translated correctly and did not omit any credible information.

Discussion of Findings Demographic of respondents
Table 1 shows the demographic profile of the respondents interviewed. Seven respondents, representing (58%) of the total participants, reported that they had worked in the department for more than 10 years, compared to five participants who represented (42%) of the respondents. Ten respondents, or (83%) of the total participants, stated that their highest qualification was a B-Tech degree. Six of which were in construction management and four in project management. Only two participants (17%) out of the 12 participants mentioned that their highest qualification was a master’s degree. Four participants (33%) said they have not registered with the South African Council for Project and Construction Management Professions (SACPCMP), whereas eight participants represented by (67%) indicated they were registered with SACPCMP.

<table>
<thead>
<tr>
<th>Participants parameter</th>
<th>N=12 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years worked at the Department of Human Settlement, Water and Sanitation</td>
<td></td>
</tr>
<tr>
<td>0-10 years</td>
<td>5 (42)</td>
</tr>
<tr>
<td>More than 10 years</td>
<td>7 (58)</td>
</tr>
</tbody>
</table>
Factors that hinder the use of project management processes in the delivery of RDP houses.

Table 2 provides the results of the identified factors that hinder the use of project management processes when undertaking RDP housing projects. The factors were distilled into themes derived from the sub-themes and codes generated by the data. Four themes, evolved in response to this objective: Lack of formalized project management manual, project management skills, resource management and stakeholder management.

Table 2: Themes, sub-themes, and codes of hindrance factors

<table>
<thead>
<tr>
<th>Objective</th>
<th>Theme</th>
<th>Sub-theme</th>
<th>Representative quotation / codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factors that hinder the use of project management processes in the delivery of RDP projects</td>
<td>Lack of formalized project management manual</td>
<td>Institutional design</td>
<td>inability to align strategies with business process &quot;misalignment between project management strategies, business process and management practices&quot; &quot;ineffective strategies to manage project&quot; &quot;inability to align project management strategies&quot; &quot;lack of use of improvement and planning tools&quot; &quot;lack of adoption of effective review process&quot; &quot;inability to follow project plan&quot;</td>
</tr>
<tr>
<td>Poor project management skills</td>
<td>Attitude</td>
<td>&quot;consideration&quot; &quot;intellectual stimulation&quot; &quot;inspiration&quot; &quot;idealized influence&quot;</td>
<td></td>
</tr>
<tr>
<td>Incompetence and communication</td>
<td>&quot;communication&quot; &quot;motivational skill&quot; &quot;organisation&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resource management</td>
<td>Poor planning and estimate</td>
<td>Budget and schedule over-run</td>
<td>&quot;poor project planning&quot; &quot;Budget constraints&quot; &quot;lack of planning and deployment&quot; &quot;inadequate estimation of</td>
</tr>
<tr>
<td>Poor contracting practice</td>
<td>claims and litigation &quot;contractual dispute&quot; &quot;delay on dependent task&quot; &quot;project abandonment&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeholder management</td>
<td>Poor communication</td>
<td>&quot;non-involvement by stakeholder&quot; &quot;misunderstanding among project team&quot; &quot;compromised quality&quot; &quot;reduced efficiency&quot; &quot;stakeholder involvement&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Source: field data (2023)

Lack of formalized project management manual

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
Respondent B identified “institutional design” as a hindering factor, where project management is not adopted as a formalized documented process to be followed. This affects how project management functions within the Department deliver its infrastructure to its clients in the city of Tshwane. Respondent C & J “the life cycle of the project is the same, but there are key administrative issues that are important to be applied and followed when undertaking such projects. Due to the fact that the Department does not have a manual/standard operating construction projects manuals for the Department it does hinder the implementation of this process”.

Poor project management skills

Respondent C indicated that, “competence is a hindering factor. Specifically looking at the knowledge, skills and competence of project managers within the Department to implement these processes. A lack of formal adoption of a manual that talks to how project management should be implemented within the institution. This exposes the weaknesses in a form of competence, knowledge and skills of the project managers”.

Respondent H shared the same sentiments of Respondent B saying that, “within the Department there are no standardized guidelines to implement project management processes”. Furthermore, respondent H echoed the words of respondent C by indicating that, “lack of project management skills amongst project managers within the Department”.

Respondent A, D, E & F “Project success rates are unquestionably significantly increased by having a thorough grasp of and use of project management. Contrary, poor project management knowledge, skill and competence have resulted in the collapse of government projects”. The majority of respondents cited the Department’s lack of a codified manual or documentation as a barrier to the implementation of project management processes. If no new approaches are taken to address the hindering factors, it is evident from the facts above that the Department will continue to have difficulties in the implementation of project management processes if nothing changes.

Lack of resource management

Financial resources was also a major hindering factor. Respondent D indicated that, “our project are always undertaken on a fixed subsidy amount, this means that there is no possibility for an increase. Underestimation by many contractors has in many instances affected the project management processes negatively”.

Respondent (A, B, C, H, & I) one of the hindering factors is poor planning of resources management during inception of a project. It can have a ripple impact on the entire workflow when there are gaps in the procedure. Respondent A, “For instance, unresolved resource allocation issues in the project can result in ineffective production, material waste, and idle equipment. As a result, problems with resource management or allocation result in a loss of project resources such as time, effort, and money. So, it’s critical to match the appropriate resources with the appropriate initiatives at the appropriate time”.

Many of our sites says Respondent (H, B, F, G & D) have delays in their work because the necessary materials don’t arrive on schedule. Some sites lack sufficient material storage. To ensure that materials are delivered on time, comprehensive resource planning and management should be carried out. Respondent D suggested that, “for instance, it will be difficult to store materials safely if they are supplied too early. However, if the materials are supplied too slowly, the projects may be delayed, or you may need twice as many resources to finish the work as planned”.

The finding of Nagaraj in (2012) agrees to this finding the concluded that no activity can be completed in the time allotted unless necessary resources are planned for and obtained.

Lack of stakeholder management

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Kgabo Cholo and Justus Ngala Agumba

Respondent K “It is usually advantageous for stakeholders to actively participate and make themselves available in any project”. Respondent (A, D, E, K, & L) indicated that failure is likely to result from poor communication throughout the planning and execution of initiatives with the stakeholders. Project success could be threatened by miscommunication. Language obstacles, cultural barriers, poor feedback, and confusing communication routes amongst stakeholders. This are just a few of the factors that contribute to poor communication in our housing projects. Respondent A & D “In pro-jects involving multicultural collaboration, the first two causes cited are pre- dominate. Ineffective stakeholder communication has also been linked to de- lays in project implementation, which ultimately leads to project abandonment and failure”.

This findings to a broader context corroborate with the findings of Li, (2013). The author suggested difficulties in managing stakeholders in building projects as, interpersonal conflicts, money issues, cultural differences, unmet expectations in contracts, and communication aperture Li, (2013).

Respondent B “For a variety of reasons, there are times when a stake- holder does not wish to attend technical meetings that are typically held on site. So, this implies that some project-related issues will halt until such a time that individual avails themselves”. Respondent F & G “The project team is not immune to conflicts or disagreements; on occasion, you may notice that particular team members are fighting, which typically has an impact on how successful project management processes are implemented”.

Conclusions

This study established the core hindering factors in the implementation of project management processes when RDP housing projects are built. The factors identified in this study are: lack of formalized project management manual which is explained by the lack of institutional design defined by “inability to align strategies with business process” “misalignment between project management strategies, business process and management practices” “ineffective strategies to manage project” “inability to align project management strategies” “lack of use of improvement and planning tools” “lack of adoption of effective review process”.

Poor project management skills was also established a challenge to the implementation of project management processes. The participants established that wrong attitude, incompetence and lack of knowledge contributed to poor project management skills that ultimately were a deterrent to the implementation of project management processes. Further, lack of resource management which was influenced by, poor planning and estimate, and poor contracting practice were detrimental to the implementation of project management processes. Finally lack of stakeholder management which was influenced by poor communication.

Recommendations and future studies

In relation to the findings, the recommendations to the Department of hu-man settlement is to ensure that formalized project management manuals are developed and adhered too. This will give guidance and aid in the implementation of project management processes when undertaking RDP houses. In addition, adequate training for the employees involved in the de-livery of RDP houses should be rendered. This will ensure that they are equipped with the required competencies to implement the project management processes in the delivery of these housing units. Therefore, building the critical institutional capacity.

The resources required for the implementation of the project management process should be adequately managed. When the resources are poorly managed, they have a negative impact on the project management processes implementation. Finally, it is imperative that stakeholders who have vested interest in the project are reached out to adequately. The lack of adequate communication could hinder the implementation of the project management processes for successful delivery of RDP houses.

From the findings, the researchers acknowledge the geographical limitation the study. The findings are
based on the Tshwane municipality in South Africa; hence the findings cannot be generalized. Further study can be conducted to include other provinces and municipalities.

References


Conceptualizing the usage of Artificial Neural Networks for Bid Evaluation.

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Abstract
Purpose of this paper
A faulty public procurement system leads to project budget overruns, inadequate quality and late completion as the direct result of appointing inadequate contractors. Often, competent contractors are chosen during the bid evaluation process when the client chooses the lowest bidder who proposes a short construction duration. Several factors contributed to the review of bid evaluation decisions, including improper use of power by a high authority, poor implementation of regulatory legislation, and lack of rational basis for decisions. It is critical to ascertain the type and storage method of past project data for evaluating future bids.

Design/methodology/approach
Literature review method was applied. In order to facilitate the process of bid evaluation, the current study explores ways to achieve historical data sharing and analysis by using artificial neural networks (ANNs).

Findings
The research has shown the importance of screening the contractors at tender stage in order to appoint the right one with minimal risks. The legislation which regulates the procurement process in the South African sector does not correlate with the usage of collected data from past projects when evaluating tenders.

What is original/value of paper. A conclusion can be drawn that ANN is a significant tool that can be used to analyse and share projects’ data for tender evaluation purpose.

Keywords: Artificial Neural Networks, Bid Evaluation, Contractor Selection, Selection Criteria, Supply Chain Management.
Introduction

A faulty public procurement system leads to project budget overruns, inadequate quality and late completion as the direct result of appointing inadequate contractors (Banaityiene and Banaitis, 2006). Likewise, Moeti (2014) argues that most government fraud and corruption occur due to poor procurement management and control, supporting Munzhedzi’s (2016) comment about R 26.4 billion spent in 2010 in ways that contravened laws and regulations. A robust process is essential when determining a competent contractor or during bid evaluation (Doloi, 2009). Often, competent contractors are chosen during the bid evaluation process when the client chooses the lowest bidder who proposes a short construction duration (Puri and Tiwari, 2014). Bid evaluation can be described as a decision-making process involving the development and consideration of suitable criteria for assessing the competence of contractors (Puri and Tiwari, 2014). Therefore, this process involves the development of selection criteria as well as a decision-making model to correlate these criteria (Pongpeng and Liston, 2003).

There are several different sets of criteria suggested in literature from diverse sources, since most organizations develop their own criteria. For instance, Ngobeni (2011) lists quality, time, delivery, service, flexibility, financial status, capabilities, ethics, and social responsibility among criteria. On the other hand, state organs do not only consider price as the only criteria, but non-price criteria also such as “functionality/quality criteria (Bolton, 2014). So, the construction procurement best practice guidelines provided by CIDB (2018) specified these functionality/quality criteria as managerial capacity, reliability, experience, and reputation, along with professional, technical, and competency skills. In these selection criteria, data from past completed projects by the contractors is undeniably a critical component. Thus, for future project evaluation, it is critical to ascertain the type and storage method of past project data. In order to facilitate the process of bid evaluation, the current study explores ways to achieve historical data sharing and analysis by using artificial neural networks (ANNs). The process can be complemented through the usage of objective information collected from past projects which can be analyzed and shared through an effective model.

Public Sector Bidding Process

According to Ngobeni (2011), South African government employs tendering (bidding) process as a method of procuring goods and services for public, which represent the large amount of public expenditure. Patil et al. (2016) defined bidding as the process of preparing and submitting, for acceptance, a conforming offer to carry out the work for a certain price. In order for the government to achieve its objectives, Thai (2017) emphasised the significance of the legal regulation of construction procurement in South Africa. It is often the case, however, that policy and legal regulation aspirations do not match reality. In South Africa, supply chain selection and preferential procurement aspects are outlined in a legislative and regulatory framework. Nevertheless, local governments and parastatals are given the freedom to develop and extend their own custom policies, systems, and structures within the national regulatory framework (Hanks et al., 2008). Despite the South African government’s commendable policy framework, its implementation is inadequate and there is external interference that serves to undermine its effectiveness (Munzhedzi, 2016).

In contrast, Bolton (2014) argues that the new preferential procurement system does not allow for the use of functionality/quality criteria. It is the uncertainties outlined in the CIDB (2008) best practice that contribute to the misuse of power, which warrants the award of the contract to a bidder other than the highest scoring. This imposes a great deal of restrictions on the objective criteria that may warrant awarding a contract. Among the court cases Bolton (2014) analysed were Mamlambo Construction cc vs. Port St Johns municipality, which held that awarding the contract to the lowest bidder lacked rational bases and did not take into account relevant factors. The fundamental question in this decision-making process is what constitutes an ‘objective’ decision.
A study by Turpin and Marais (2004) examined the relationship between several theoretical decision-making models and the practice used by senior managers. This research will consider the rational model as well as the organizational procedures view model, among others. In the rational model, each alternative is assigned a numerical value or utility during the selection process (Turpin and Marais, 2004). A similar method is used by the South African public sector, known as the “point scoring method” (CIDB, 2008). To a maximum of 100 points, points are allocated to the financial offer, preferences, and quality criteria. For instance, the threshold (financial offer and quality/preferences) for 80/20 and 90/10 preferential rules are for a contract value of between R 30 000 to R 1 000 000 as well as above R 1 000 000, respectively.

Similarly, in the organisational procedures view, decisions are the outcome of standard operating procedures invoked by organizational subunits (Turpin and Marais, 2004). In other words, the decisions are pre-programmed based on the existing procedures and the routine thinking of the individuals involved (Turpin and Marais, 2004). Government institutions that operate within set regulatory frameworks will find this to be extremely useful. This data can be leveraged by the government for future cases in light of the unified decisions for past projects from various departments. The review of South African government Supply Chain Management has shown that reformation will require collaboration and it should be treated as a national project to realise benefits, amongst others, such as increase in good-quality service delivery; economic growth as economic infrastructure expands and efficiently maintained as well as substantial decrease in cost of acquiring goods and services (National Treasury, 2015). The later study revealed the lack of strategic approach in trying to integrate the supply chain, which can yield results such as improving value, eliminate inefficiencies as well as reducing project costs (Khalifan and McDermott, 2006, Pillay and Mafini, 2017). There is therefore a dearth of a database containing past projects that can be used to evaluate bids in the future.

**Research Method**

The research is exploratory of bid evaluation process using artificial neural network and it involves conceptual analytical approach. Furner (2004) defined conceptual analysis as a technique (i.e. defining the meaning of a given concept precisely by identifying and specifying the conditions under which any entity or phenomenon is classified under the concept in question) that treat concepts as classes of objects, events, properties or relationships. The literature review method was used whereby literature related to the bid evaluation was used as well as exploring various studies pertaining to the application of ANNs in construction sector. A variety of sources were consulted, including journals, conference proceedings, government documents and reports. A computer database was used because it is more efficient and quicker to retrieve vast amounts of information than a manual search (Ramdhani et al., 2014). Consequently, search words included bid evaluation, contractor selection and artificial neural networks. These were used along with “public procurement” and “construction industry”.

**Introduction to Artificial Neural Network**

There are several theoretical frameworks and models currently used to evaluate construction tenders (Puri and Tiwari, 2014). Banaitiene and Banaitis (2006) allude to several tender evaluation model, such as multi-criteria complex proportional assessment, the fuzzy neural network which comprises fuzzy set and neural network theories, the stochastic model to compare the expected prices, and the automated model for the pre-bidding process in order to enhance efficiency in the bidding process as well as minimising human error and the risks. The research community (Khosrowshahi, 1999; Banaitiene and Banaitis, 2006; Oladapo and Odeyinka, 2006; Doloj, 2009; Zhang and Wang, 2011; Bergman and Lundberg, 2013) has endorsed developments in this direction. The purpose for these models is to forecast the performance of potential contractors before they are appointed and address both linear and nonlinear aspects of contractor evaluation.
Artificial neural network (ANN) is a computational mechanism that have the ability to acquire, represent and compute function from one multivariate space of information to another, given a set of data representing that function (Waziri et al., 2017). Other researchers have simplified the artificial neural networks as the data processing technology that simulates the human brain and the manner which a human learn (Anantwar and Shelke, 2012; Boussabaine, 1996). Similar to human brain, neural network learn from past experience, generalising from previous examples to new one as well as to abstract essential characteristics from inputs containing irrelevant data (Boussabaine, 1996). Waziri et al. (2017) further explained that ANN is composed of a large number of highly interconnected processing elements called neurons working in unison to solve specific problems.

A typical ANN structure comprises of three layers, namely: input, hidden and output layer (Ahiaga-Dagbui, 2014). The input layers accept data presented to the network and assigns weights according to the relative importance or sensitivity of information. Neural network’s computations happen within the hidden layer (middle section), which also becomes the permanent memory of the model after training for predicting new cases. The output layer of the neuronal network is a function of the weighted sum of all neurons in the network, a completely deterministic result (Ahiaga-Dagbui, 2014). Below figure show the neural networks’ structure.

![Neural network structure](image)

Fig. 1. Neural network structure (Adopted from Waziri et al. (2017))

From the above figure, as values are sent from input layer to hidden layer, the weight is assigned to each interconnecting line and is multiplied by the values (Sibanda and Pretorius, 2012). Input information is presented to the neural network for each sample together with envisaged results. The system will then calculate an output value based on the information given (input) multiplied by respective weight (in hidden layer) and the results will then be compared with the target value predetermined. The difference in results obtained versus what was predetermined yields the system output error and the system training must be repeated until the results are satisfactory (Anantwar and Shelke, 2012; Boussabaine, 1996).

### Types of Artificial Neural Networks

The study has revealed the following four different types of artificial neural networks currently used (Sibanda and Pretorius, 2012):

- **Feedforward Neural Networks**
- **Feedback Neural Networks**
- **Self-Organising Neural Networks**
- **Recurrent Neural Networks**
Feed-forward Neural Networks
Feed-forward has been classified as the first and simplest type of artificial neural networks. The flow of information is in one direction, being forward from the input nodes through the hidden nodes and to the output nodes. Feed-forward neural networks divided into single layer perception (SLP) and multi-layer perception (MLP) types. SLP networks has only single layer of output nodes and the inputs are fed straight from the outputs through a series of weights. On the other hand, MLP networks consist of multiple layers of computational units which are interconnected in a feed-forward manner. Anantwar and Shelke (2012) argued that the logic for the overwhelming use of MLP is due to the fact that such network construction is akin to multivariate non-linear regression model.

Recurrent networks
Contrary from feed-forward networks, recurrent networks are models comprises of bi-directional data flow. Though a feed-forward network transmits data linearly from input to output, recurrent network also transmit data from later processing stages to earlier stages. Recurrent networks are divided into simple recurrent network (SRN) and Hopfield Network types. SRN is just a variation of the MLP whereby a three layer network is used together with the addition of a set of context units fixed with weights of one. SRN is applied for sequence prediction that is beyond the power of a standard MLP. Hopfield networks are simply a recurrent neural network in which all connections are symmetrical and it warrants that its dynamics will converge.

Stochastic neural networks
Stochastic neural network introduces random variations into the network, which makes it different from a regular neural network.

Modular neural networks
Modular neural network is characterised by a series of autonomous neural networks moderated by some intermediary. One of the notable advantages of modular neural networks is its ability to reduce a large neural network to smaller and more manageable components. Modular neural networks are divided into committee of machines (CoM) and associative neural networks (ASNN) types. CoM is a collection of various neural networks that decide and vote on a given example with a hope of cancelling errors as there are several experts, altogether. This renders much better result compared to other neural network models. ASNN represents a combination of feed-forward neural networks to correct the bias of the neural network ensemble.

Advantages and disadvantages
The advantages of an artificial neural networks include its property of universal approximation whereby it is endowed with a finite number of hidden unit and yet can approximate any continuous function to any desired degree of accuracy; it does not need prior knowledge of the data generating process to be implemented and also no problem of model misspecification occurs (Anantwar and Shelke, 2012).

The shortfalls of ANN, on the other hand, includes too many hidden units addition which incite the problem of over fitting the data; the process of constructing an effective model is time-consuming as it involves too many trial and error activities (Anantwar and Shelke, 2012). Boussabaine (1996) alluded that the predictive nature of artificial neural networks analysis, in particular for non-linear cases, will be an invaluable assistant especially in the fields requiring analytical tools for integration into the decision-making process.

Training
Training pertains to the process during which input data is incorporated into the network alongside with its corresponding output values so that the network can adjust the weights in order to generate the given input and output vectors with minimal to no error (Anantwar and Shelke, 2012). Apanavičienė and Juodis (2003)
argued that the primary goal of training neural networks is to find the functional relationship between the input patterns and target outputs. The supervised, unsupervised as well as the reinforcement learning are the most commonly used training methods (Boussabaine, 1996).

Supervised learning method, which is the paradox of unsupervised, is used when the system is presented with the set of inputs from the external environment together with desired output the network is expected to deliver (Boussabaine, 1996). On the other hand, reinforcement learning method only requires a set of inputs and only a grade as output (Boussabaine, 1996). Though there is no specific formula to select method to use, the selection of training method is mainly dependant on the problem in question as well as the data available.

Application of Artificial Neural Networks

A wide variety of tasks have been tackled with artificial neural networks, which are classified as prediction, approximating functions, and recognizing patterns. Prediction involves the estimating of the future trends in a time series data using current and previous circumstances (Sibanda and Pretorius, 2012). Function approximation is concerned with modelling the relationship between variables while pattern classification involves classifying data into distinct classes (Sibanda and Pretorius, 2012).

A number of notable sectors such as financial services, mining, medicine, engineering, and physics have successfully manipulated artificial neural networks (Apanavičienė and Juodis, 2003, Sibanda and Pretorius, 2012). For instance, Artificial neural network is used in finance for stock market prediction, crediting rating, bankruptcy prediction as well as the economic indicator forecasts (Sibanda and Pretorius, 2012).

Other noteworthy example of successful usage of neural network in engineering, whereby Marwala (2000) developed an artificial neural network model used to identify damage in mechanical systems using committee on neural networks. Sibanda and Pretorius (2012) broadly explored various usage of artificial neural networks in the modelling of HIV epidemic. Neural networks, unlike other statistical techniques, make no prior assumptions concerning the data distribution and can model highly non-linear functions and be trained to precisely generalise when presented with new and previously unseen data (Sibanda and Pretorius, 2012).

Artificial Neural Networks' application in construction

ANN is not new in the construction sector as it has gained considerable application in construction engineering and management in recent time and it has been used to predict tender prices, construction costs, cash flow, labour productivity, contract performance, mark-up estimation (Waziri et al., 2017). Various models have been developed to improve the tendering process globally. Muqeem and Idrus (2011) developed an artificial model used to predict construction labour production rates. The model aimed at incorporating subjective factors such as weather, which hinders the construction labour rate output. The test results and application of the model were satisfactory and met the envisaged objectives.

Al-Sobiei et al. (2005) also developed a model using artificial neural networks and genetic algorithm techniques to predict risk of contractors' defaulting in Saudi Arabia. The model is used to assist the construction clients to analyse the risks of contractors' defaulting on a project prior to appointment. Though the testing of the model was successful, it cannot be generalised due to small number of training done.

An artificial neural model was developed by Khosrowshahi (1999) to assess contractors' prequalification for local authority projects in United Kingdom. Testing results revealed highly satisfactory predictive accuracy. The model is only useful when screening the contractors if they qualify to tender for local authority projects. similarly, El-Sawalhi and Hajar (2016) developed an artificial model for construction contractors awarding system in Gaza strip. The results of the trained model was successful and indicated 95.96% accuracy. The study did not distinguish whether it was done on public or private sector.
Furthermore, Zhang and Wang (2011) developed an artificial neural network model which automatically evaluates tenders on a computer. The model designed is comparatively suitable to solve tender evaluation process shortfalls which are analysis indexes that are non-linear related in the tenderer and tender bidding. The experiment data shows the reliability of the bid evaluation done using the model (Zhang and Wang, 2011). The variable used to develop the study was not properly explained and therefore cannot be fully adopted everywhere.

The artificial neural network has gained considerable attention from researchers in the procurement process for construction projects. Moreover, Anantwar and Shelke (2012) concluded that neural networks are flexible and can be used to solve almost any problem with historical data and the need to develop a model based on it. For an ANN model to be effective for tender evaluation, historical data must be available for training as well as predetermined results.

**Lesson Learnt**

The literature reviewed has shown the importance of screening the contractors at tender stage in order to appoint the right one with minimal risks. Several factors contributed to the review of bid evaluation decisions, including improper use of power by a high authority, poor implementation of regulatory legislation, and lack of rational basis for decisions. Also, the legislation which regulates the procurement process in South African sector does not correlate to the usage of collected data from past projects when evaluating tenders. Consequently, this loophole renders the process subjective, ineffective and challengeable in court. Moreover, the South African government has shown commitment to improve the supply chain management through national collaboration in order to realise the objectives such as delivering good-quality service, economic growth and reducing cost of acquiring services. Artificial Intelligence is increasingly being used to complement service provision in a variety of sectors. As a result, various Artificial Neural Network models are developed within the construction sector, specifically for improving tender evaluation process. Collected data from previous projects are used as the variables for training ANN models. Lastly, the competitive advantage of ANN is the ability to acquire and analyse information same way as human.

**Conclusion**

In this study the procurement process used in South Africa as well as the tender evaluation process was discussed including the shortfalls. The system was deemed inadequate and therefore needs further improvements. The study has revealed the importance of implementing an effective system of evaluation tender in order to determine the risks of contractors’ defaulting or likelihood of successfully completing the project. The study further explored the usage of ANN particularly in construction tender evaluation process. Various models has been developed and proven to be effective for tender evaluation. However due to special segments within South African legislations which regulates procurement process, such models cannot be easily adopted without modification. Data used as variables for the developed model cannot be generalised. Therefore, conclusion can be drawn that ANN is a significant tool that can be used to analyse and share projects’ data for bid evaluation purpose. Its ability to learn, nonlinear approximating and flexibility can ensure tender evaluation to be effective, fair and objective. The study is at its preliminary stage of gaining an understanding of incorporating historical data to evaluate public sector construction bids using ANN model, aligning to the South African procurement legislation and regulatory frameworks.

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ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa


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Shopping Centres and Approximate Residential Property Prices: A Case Study: Windhoek, Namibia

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ABSTRACT

Purpose
Over the last few decades, the quantity and scale of retail shopping centers located in residential neighborhoods or close to them has increased in Namibia’s real estate market. These shopping malls have the potential to have both positive and negative effects, which can then be reflected in the pricing of nearby residential properties. This paper investigates the impact of the Grove Mall Shopping Centre on the price of approximate residential properties.

DESIGN/METHODOLOGY/APPROACH
The study reflects on a quantitative study conducted in Namibia to investigate the impact of the Grove Mall Shopping Centre on the pricing of approximate residential properties.

FINDINGS
The study’s findings show that, in the case of the Grove Mall Shopping Centre, the latter resulted in an increase in residential property prices in its nearby suburbs, Kleine Kuppe, Cimbebasia, and Olympia.

VALUE
The study highlighted variables that would remain robust predictor of residential property price changes in the overall dataset used. These variables must be identified and highlighted often to prevent nuances in the residential property market dynamics compared to the overall trends in the property market.

Keywords: Shopping centres, inflation, Residential Property Price, hedonic methods
1. BACKGROUND OF THE STUDY

Immovable properties are heterogeneous in nature, which means that the value of one real property is not equal to the value of another. Heiniger et al., [1]. The market value of immovable property can be defined as the amount which a property can realize if sold on the date of valuation in an open market by a willing seller to a willing buyer Perspective-Value-Market-An Established-Basis- of Value-Web [2]. The deficit in affordable housing supply; due to the scarcity of housing has caused residential property prices to reach a new high, and it has continued to do so for the last decade and a half. Remmert and Ndlovu [3] states that the most recent official estimate of Namibia’s backlog from the [4] is put at 300,000. Namibia’s urban population is expected to increase from 52% to 60% by 2030, the country’s demand for formal housing is increasing with urbanization and offers a key economic opportunity Remmert and Ndlovu [3]. The country is experiencing an annual urbanization of around 3.8%, translating to 50 000 people or 13 500 new urban households, annually. The paper provided insight into the factors that affect residential property prices in Namibia, which can help effectively manage the residential property market.

The study employed a quantitative study using quantitative data. A linear regression model was chosen using attributes in hedonic method found in Residential Property Price Indexes (RPPI). Hacievliyagil, et al [5] states that individuals and organizations use the (RPPI) directly or indirectly to influence practical decision-making or inform the formulation and conduct of economic policy. The Grove Mall Shopping Centre and approximate residential property prices is considered a unique phenomenon that has not been studied extensively in the Namibian context. To effectively manage the residential property market efficiently, there is a need for a deeper understanding of the factors that affect residential property prices. This research is part of an effort to replicate studies that were done in other countries on the same topic to see if the findings can apply to Namibia. The study evaluated the spillover impact of commercial shopping centres on residential property prices as well as rentals using the Grove Mall as a case study. The limitation of the paper is that the research philosophy is a case study in Windhoek on the Grove Mall and residential property prices in the selected neighboring suburbs, namely Kleine Kuppe, Cimbebasia, and Olympia. As a result, the study's conclusions may not be applicable to other locations or countries. Furthermore, due to the restricted information available at the time of the study, the study period is confined to 2009 to 2019. As it stands currently the information is loaded manually on the system by the Deeds office.

2. REVIEW OF LITERATURE

2.1 Factors that affect property prices

2.1.1 Land

Vision 2030 [4] declares that there is a legislative framework to guide the process of land acquisition in Namibia. Remmert and Ndlovu [3] states that the major factor that determines the price of a property in Namibia is the availability of land that is serviced for the building of housing properties. The same author noted that the non-availability of land that was ready for building property is the dominant factor driving the price of land up in the country. The county found that locational factors and proximity to social amenities are fundamental in the understanding of factors influencing property values. Sale [6] observe in a study that was done in the Warner area of Port Elizabeth and notes that Properties that were located at Warner Park in the Port Elizabeth area enjoyed higher property values than those that were located far away from the shopping centre. The study by Oloke et al., [7] draws the conclusions that variables that impact on property values included (i) proximity to waste site, nearness to schools, proximity to highway, nearness to shopping centres, and nearness to the airport. Nearness to the highway was considered a significant variable for determining the value of properties. The proximity to the airport was the least popular variable in the findings when it comes to determining the value of properties. Zin et al., [8] conducts a study in Malaysia the determinants of heritage property value. The study was based on scrutiny of papers located in databases and retrieved from 1974-2017. The research identified
four themes that emerged from the data namely the “transition characteristics, structural characteristics, spatial characteristics, and historical characteristics” Zin et al., [8]. The determinants of Heritage property value have been enumerated as “Locational, neighbourhood, and housing structural factors” Zin et al., [8].

2.1.2 Improvements

For starters, owning improves residential mobility, people’s health, and other social outcomes. Dietz et al., [9]. Secondly, housing is good, which is closely connected with other markets and the whole economic status of the country. Ferlan et al., [10] notes that several factors influence property value. Some of the factors that were observed to influence property value in South Africa are the number of stories, presence of a swimming pool, availability of an electric fence, age of the house, number of bathrooms, and distance of the property from the shopping centre.

The impact of housing on economic and social variables necessitates an examination of the causes of housing prices. Because houses can be purchased using mortgages as well as the residents’ own finances, Cohen et al., Vision 2030 [4], Cohen and Karpavičiute [11] underline that the housing market is particularly tied to the financial sector.

2.1.3 Date of Valuation

The second most significant variable identified in this was the proximity to shopping centres and schools Oloke et al., [7]. Monitoring the development of house prices is considered important, especially in times of economic turbulence Oloke et al., [7]. Finally, the changes in housing prices influence the construction market and other economic variables such as unemployment and inflation, because of this, a lot of analysis have been done in developed countries. These analyses primarily focused on economic and financial determinants of housing prices, such as GDP, unemployment, interest rates, and credit conditions Jacobsen and Naug [12], with a few exceptions focusing on demographic variables such as population, ageing, and migration. Larson [13] elaborates that macro-economic factors denotes factors that are linked to “demand and supply, gross domestic product (GDP) unemployment, household income, interest rate and so on. However, the causes of property prices in Lithuania do not necessarily correspond with those in developed nations, owing to historical characteristics of a planned economy and transition processes to a developing economy.

2.1.4 Purchase price

Sunde and Muzindutsi [14] believe that Namibia has seen a significant increase in the prices of housing properties. The same author noted that the rise in the prices of houses has been unprecedented, and the country risks experiencing a sudden economic recession. The Handbook on Residential Price Indexes [15] classifies the uses of residential property prices as follows: (i) to provide guidance for those wishing to establish or modify existing indices in light of international harmonization; (ii) to provide a discussion and comparison of the various targets and their corresponding conceptual frameworks; and (iii) to provide an inventory of existing practices. This study used the same principles to outline literature in Namibia due to the following: a) there are many areas of society where individuals or organisations use residential property price indices (RPPI) directly or indirectly either to influence practical decision making or to inform the formulation and conduct of economic policy. b) from an individual household’s perspective, real estate often represents the single largest investment in their portfolio. It also accounts for the largest share of wealth in most Nations’ balance sheet. c) In a larger sense, analysts, policymakers, and financial institutions track home price changes to better understand real estate and credit market conditions, as well as to track the influence of economic activity, financial stability, and soundness. d) the (price determinants) attributes and individual houses frequently change over time; these changes include improvements to dwelling in the form of renovations to kitchens and bathrooms, replacement windows within, and other features that reflect many countries’ recent trend toward larger houses. In analysing residential
property prices, Namibia needs to consider the availability of credit, as the latter is seen to have more influence than interest rates in determining the price of housing. Rural-to-urban migration has been perceived as one of the major variables in the rise of the price of properties in Vision 2030 [4]. Colwell and Dilmore [16] mention that Haas produces a hedonic study more than 15 years prior to Court, who first published the term "hedonic." Etymologically, the term "hedonics" is derived from the Greek word *hedonikos*, which simply means pleasure. In the economic context, it refers to the utility or satisfaction one derives from the consumption of goods and services. Two main approaches contributed greatly to the theoretical work on hedonic prices. The first approach was derived from Lancaster [17] consumer theory, and the second comes from the model postulated by Rosen [18]. These approaches aimed to impute prices of attributes based on the relationship between the observed prices of differentiated products and the number of attributes associated with these products. The Lancasterian model, Rosen's model, and the hedonic price model all surmised that goods possess a myriad of attributes that combine to form bundles of characteristics (or objectively measurable, utility, affecting attributes), which the consumer values; but these models have some fundamental differences. The Lancasterian model presumes that goods are members of a group and that some or all the goods in that group are consumed in combinations, subject to the consumer's budget. In comparison, Rosen's model assumes there is a range of goods, but that consumers typically do not acquire preferred attributes by purchasing a combination of goods. In contrast, Rosen [18] postulates. A nonlinear price function implies that the implicit price is not a constant, but a function of the quantity of the attribute being bought, and, depending on the actual functional form of the equation, on the quantities of other attributes associated with the good as well. Zhang et al. [19] is of the opinion that the hedonic price model has been employed at a limited level to analyze housing pricing. However, the method used to quantify house price development differs by country, and even within a country, there are occasionally two or more competing methods in use. This scenario is obviously not conducive to the establishment of consistent policy measures based on meaningful international comparisons.

3. METHODS

3.1 Objective

The study reflects on a quantitative study conducted in Namibia to investigate the impact of the Grove Mall Shopping Centre on the pricing of approximate residential properties.

3.2 Data Collection Method

The paper focused on the residential property prices in the selected neighboring suburbs of the Grove Mall, namely Kleine Kuppe, Cimbebasia and Olympia. The study tested the following hypothesis: HO: There is no relationship between the prices of neighboring residential properties and the construction of the Grove Mall

H1: There is a relationship between the prices of neighboring residential properties and the construction of the Grove Mall. The secondary data collected for the study were sales records from 2009 up to 2019, which is five years before the Grove Mall and five years after the Grove Mall. The questionnaires were the primary data distributed to property owners in the area; demarcated and verified using Microsoft word and analyzed through SPSS in order to analyze the opinions and individual preferences of residential property owners. Secondary data used the SPSS software to clear duplications and basic data cleansing and thereafter data was analyzed using the ANOVA model and descriptive statistics. The study employed the One-way ANOVA to compute the power of an experiment designed to determine if more than two data sets are significantly different from each other. The $R^2$ is applied as a simple correlation to reflect whether there is a correlation between the dependent variable (Purchase price). The amount of variation between variables can be explained by the independent variable. The quantitative phenomenological approach was suitable as the Likert scale questions in the questionnaire were used to explore in-depth experiences and perceptions of the phenomenological data that might inform understanding. The quantitative phenomenological approach to the data information from the City
3.3 Ethical consideration in quantitative data collection and analysis

The cornerstone of ethical research is 'informed consent' (Fleming et al.,[21]). The term consists of two important elements, each requiring careful consideration: 'informed' and 'consent.' Respondents were informed of what will be asked of them, how the data will be used, and what (if any) consequences there could be. The respondents were requested to provide explicit, active, signed consent to take part in the research, including understanding their rights to access their information and the right to withdraw at any point. The informed consent process can be seen as the contract between the researcher and the respondents. The aspects of 'informed' included a clear explanation on the most crucial aspects.

4. SAMPLE SIZE

The selection size of the residential homeowners was based on a geographical map on the database of the City of Windhoek cadastral map depicting the demarcation of the different properties as well as their distance from each other. According to Saunders et al. (2012), the advantage of a smaller sample is that it allows for more focused and precise information for the research. A simple random probability sampling was used for the selection of the residential homeowners that own residential properties in the vicinity of Grove Mall (sample size). The sample size for the questionnaire survey was determined by the formula below.

Where \( N \) is the population size (2500),
\( \varepsilon \) is the margin of error (10),
\( z \) is the confidence level (as a z-score) and
\( p \) is the population proportion of 50%.

With the above formula and calculation, the sample size of 93 was calculated, and the latter was rounded off to 100 to cater to the possibility of a low response rate.

5. RESEARCH FINDINGS/RESULTS

The availability of data on the histogram is skewed to the right; the proportion of data is concentrated on the left side of the distribution, and this is an indication that the value of the mode is the lowest. Most of the purchase price falls between $0 and $2 million. The purchase price is thus not normally distributed. The scatter plot indicates that there is a linear relationship between the purchase price and the year the property was purchased. Year of purchase has everything to do with the construction of the Grove mall because the Grove mall was constructed in 2014 and also the time that the price of residential property spiked. It is also observed that there are a few outliers in the prices of neighboring residential properties after 2014. This indicated that there is a linear relationship between purchase price and the year; hence, the study went ahead and performed a linear regression.
Figure 1 shows the relationship between purchase price and the purchase year of residential property prices.

Table 1: Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase Price</td>
<td>2465</td>
<td>707.00</td>
<td>125,800,000.00</td>
<td>1,542,747.22</td>
<td>4,370,553.87</td>
</tr>
<tr>
<td>Purchase Year</td>
<td>2465</td>
<td>2009</td>
<td>2019</td>
<td>2012.79</td>
<td>3.049</td>
</tr>
<tr>
<td>Inflation</td>
<td>2465</td>
<td>2.46</td>
<td>9.28</td>
<td>5.3594</td>
<td>1.50994</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>2465</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 depicts an average price of 1,542,747.22, a maximum purchase price of 125,800,000.00, and a standard deviation:

The coefficient of variation is 283.27%, which is a measure of how much data is far apart from the mean, the purchase price indicates that the price is very dispersed, that is evident from the minimum purchase price of N$ 707.000 and a maximum of 125,800,000.00.

Table 2: Model summary

The Durban-Watson shows that it is within the acceptable range of 1.5 to 2.5 indicating that there is no serial correlation among the errors in the purchase price. This means that 3.1% of property prices can be explained by the year of purchase and hence the construction of the Grove Mall.
Table 3 depicts the ANOVA table, which reports how well the regression equation fits the data (i.e., predicts the dependent variable) and is shown above. This table shows that the regression model accurately predicts the dependent variable. Go to the "Sig." column in the "Regression" row. This indicates the statistical significance of the regression model that was run. Where \( p < 0.05 \), which is less than indicating that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data).

**Table 4: The coefficients table.**

Table 4 depicts the coefficients table that provides us with the necessary information to predict the purchase price from the purchase year as well as determine whether the construction of the Grove Mall contributes statistically significantly to the model (by looking at the "Sig." column). Furthermore, we can use the values in the "B" column under the "Unstandardized Coefficients" column, as shown above: the statistics are significant. The variable "date" determines was divided into two parts, before and after the Grove Mall was constructed.

**Table 5: Factors that affect residential property prices in the Grove Mall neighborhood**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Regression weight</th>
<th>t- test</th>
<th>Significance</th>
<th>Beta Coefficient</th>
<th>( R^2 )</th>
<th>Hypothesis Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>The Grove Mall</td>
<td>4.048</td>
<td>0.000</td>
<td>0.081</td>
<td>0.007</td>
<td>Yes</td>
</tr>
<tr>
<td>Suburb</td>
<td></td>
<td>7.352</td>
<td>0.000</td>
<td>0.147</td>
<td>0.021</td>
<td>Yes</td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td>8.278</td>
<td>0.000</td>
<td>0.81</td>
<td>0.033</td>
<td>Yes</td>
</tr>
<tr>
<td>The Purchase price</td>
<td></td>
<td>9.926</td>
<td>0.000</td>
<td>0.177</td>
<td>0.031</td>
<td>Yes</td>
</tr>
<tr>
<td>Purchase Month</td>
<td></td>
<td>0.424</td>
<td>0.6720</td>
<td>0.009</td>
<td>0.0</td>
<td>No</td>
</tr>
</tbody>
</table>

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Table 5 depicts the extent to which the dependent variables, e.g., Grove mall, 0.007%, the suburb (0.021%), size 0.033%, and purchase price 0.031% affect the purchase price. Table 5 shows a correlation between all the variables. It is evident that in this table, the purchase price, the dependent variable, has a positive correlation with all five variables (the Suburb, the Grove Mall (Before and after it was constructed), the Purchase Year and the Purchase month). However, for inflation, there is a negative relationship, indicating that as inflation increases, house prices decrease. The strongest correlation is observed between the suburb and the size of the property ($R^2 = 0.033$), the purchase year and the Grove mall ($R^2 = 0.031$), the purchase price and purchase year ($R^2 = 0.031$). An R value less than 0.05 indicates a weak correlation, whereas 0.05 and more indicate a stronger correlation.

<table>
<thead>
<tr>
<th>Purchase year</th>
<th>8.926</th>
<th>0.0000</th>
<th>0.177</th>
<th>0.31</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>-0.5562</td>
<td>-0.011</td>
<td>0</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 shows the average amount of residential property prices realized before the Grove mall was built and after the Grove mall was built. It shows that the neighboring suburb mall has realized the highest price after the mall has been constructed.

6. DISCUSSION

6.1 Restating the main results.

The section above is a summary of the entire output of the regression analysis. The hypothesis for the study was to indicate whether there is a relationship between the approximate residential property prices and the construction of Grove Mall in October 2014. The table above indicates a summary of the output results from SPSS that indicates the $R^2$, which is the correlation between the dependent variable (property prices) and the independent variables. Table 5 shows six values. The “Regression Weight” is the variable that was tested against the dependent variable, “Property prices”. The t test determines the significance of the variable, the beta coefficient, and whether we fail to reject the hypothesis or not.

6.2 Comparing the result with literature.

In the case of New Zealand, it was noted that the price of houses tended to be influenced by the distance between the houses and the beach. Zhang et al., [19] conducted a study to determine the impact of shopping malls on the housing market. Even though the study found that the Grove mall had an influence on the price of approximate residential property. The study established that by means of triangulation that size of the erf size, inflation, the year, and month had also a significant impact on residential property. The latter confirms the
findings from study by Sunde and Muzindutzi [14] that the drivers of the price of a property in Namibia are GDP, "mortgage loans, inflation, changes and population" the other researcher Sale [6] in his study noted that the location of the shopping centre did not affect the price of the residential unit although the area had challenges such as increased traffic, noise, and localized pollution, this research is contrary to the study above as the construction of the Grove mall did cause the residential property prices to spike.

6.3 Explanation of the results

The results showed an increased in residential property prices contrary to a study done by Sale [6], where the residential property prices remained unaffected. What the study can deduct from both results is that challenges emanating from increased traffic, noise and localized pollution, could have been quantified ineffectively into the residential property prices in question Rosen [18]. The reveal that the deficit in affordable housing supply; due to the scarcity of housing has caused residential property prices to reach a new high, and it has continued to do so for the last decade and a half Remmert and Ndhlovu [3].

6.4 Interpretation of results

(i) Purchase price by the Grove mall construction: the Purchase price and Grove mall construction, testing against the p-value = 0.05, the significant value for the Grove mall is less than 0.05 hence, we reject the null hypothesis. This concludes that the construction of the Grove Mall has increased the prices of properties in the areas of Olympia, Cimbebasia, and Kleine Kuppe; hence, an increase in malls will increase the price of properties. On the other hand, the R² indicates that the construction of Grove Mall increased the prices of properties by 0.007%. Since the construction of the Grove Mall only increased prices by 0.007% the study decided to look into other variables that could have influenced the price of properties in these three suburbs. (ii) the purchase price by suburb: the purchase price and suburb; testing against the p-value = 0.05, the significant value for the suburb is less than 0.05 hence, the study rejected the null hypothesis. This concludes that the Suburb has increased the prices of properties in the areas of Olympia, Cimbebasia, and Kleine Kuppe; hence, an increase in shopping malls will increase the price of neighboring residential properties. On the other hand, the R² indicates that the suburb increased the prices of neighboring residential properties by 0.021%. (iii) the purchase price by property erf size: the purchase price and property erf size; testing against the p-value = 0.05, the significant value for the property erf size is less than 0.05 hence, the study rejected the null hypothesis. This concludes that the size of residential properties has increased the prices of properties in the areas of Olympia, Cimbebasia, and Kleine Kuppe; hence, an increase in shopping malls will increase the price of properties. On the other hand, the R² indicates that the property erf size increased the prices of properties by 0.033%. (iv) Purchase price by purchase year: the purchase price and purchase year; testing against the p-value = 0.05, the significant value for purchase year is less than 0.05 hence, the study rejected the null hypothesis. This concludes that the purchase year has increased the prices of properties in the areas of Olympia, Cimbebasia, and Kleine Kuppe; hence, an increase in the purchase year will increase the price of properties. On the other hand, the R² indicates that the property year increased the prices of properties by 0.031%. (v) the purchase price by the purchase month: the purchase price and the purchase month; testing against the p-value = 0.05, the significant value for the purchase year is more than 0.05 hence, the study rejects the null hypothesis. This concludes that the purchase month has no significant value in predicting property prices; in fact, with R² = 0.000 there is no relationship between the purchase month and the purchase price. (vi) Purchase price by inflation: Purchase price and inflation value, testing against the significant value of 0.05 for the purchase year, is more than 0.05 hence, we reject the null hypothesis. This concludes that the purchase month has no significant value in predicting property prices; in fact, with R² = 0.000 there is no relationship between the purchase month and the purchase price. Since our dependent variable is the price of properties, the study decided to do further
testing, separating suburb by suburb, in order to determine how the specific suburbs were affected by the construction of the Grove Mall.

7. CONCLUSION & RECOMMENDATION

The study confirms that even though the construction of the Grove mall has increased the prices of properties in the areas of Olympia, Cimbebasia, and Kleine Kuppe, other variables also influenced the price of properties during the period under study. In short, the residential properties that were found to have realized the highest price in the period under study were found in Kleine Kuppe. The only logical explanation that the researcher could use to justify the norm was that, of the three suburbs under study, Kleine Kuppe is where the mall is situated. The causal effect of the finding is that if the Namibian government does not find a way to control residential property prices, some homeowners might default on their mortgage and lose their home. The government must introduce stricter measures to compel commercial banks to employ skilled and knowledgeable valuers that understand all factors that affect residential property values and know how to incorporate these valuation models. The study recommends that researchers look into the valuation models and practices employed by commercial banks in Namibia when they value residential properties.

8. REFERENCES


Elizabeth Tuaire, Innocent Musonda and Adetayo Onososen

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Evaluating the causes of poor delivery of Social Infrastructure Projects: A case of Limpopo and Mpumalanga provinces

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ABSTRACT

Purpose
Social infrastructure projects (SIPs) in South Africa are important for the social and economic benefits of its citizens. However, the delivery of some of these projects has been unsatisfactory in the Mpumalanga and Limpopo provinces of South Africa. Therefore, this study determines the causes of poor delivery of SIPs in these provinces in South Africa.

Methodology
A quantitative research approach was used, and data was collected using a structured questionnaire survey administered to the client representative, contractors, consultants, and other construction workers who worked on these projects. Statistical Package for Social Sciences (SPSS) version 28.0 was used to analyse the descriptive and inferential statistics of the causes of poor SIP delivery. The causes were determined using a mean score and a t-test. These parameters were supported by validity and reliability tests.

Findings
The t-test results revealed that the respondents significantly agreed that community protest, lack of funds leading to site closures, discrepancies in the bills of quantities, variation orders, and poor budgeting cause poor delivery of SIPs.

Limitations
The study was limited to Mpumalanga and Limpopo provinces in South Africa; hence, the findings cannot be generalised.

Practical implications
This study makes a significant contribution to the improvement of SIP delivery by highlighting the underlying factors that lead to poor delivery of SIPs within the provinces of Limpopo and Mpumalanga.

Keywords: Causes, Poor Delivery, Social Infrastructure Projects.
1. INTRODUCTION

The construction industry is vast, complex, and diversified. It constitutes one of the largest contributors to global gross domestic product. The global construction industry is worth more than $3.9 trillion every year (Mahamid, 2013:608). The construction industry contributes significantly to the economic expansion of developing countries. This is evidenced by the building of infrastructure required for economic growth and development (Dithebe et al., 2018:1873). Construction projects in South Africa’s public sector are referred to as SIPs. The SIPs support the local economies of the areas where the projects are based by creating work opportunities (Hussein and Omar, 2011:29). According to Perkins (2011:32), the public sector spent an average of 4% of South Africa’s gross domestic product (GDP) on economic infrastructure between 1960 and 2009. This includes funding for SIPs such as health and education infrastructure. However, in spite of the importance of SIPs and the construction industry’s economic impact, only 26% of SIPs were reportedly delivered on time in the province of Mpumalanga during the 2016–2017 fiscal year (Mpumalanga Department of Public Works, Road, and Transport, 2017:30). 53% of SIPs in the 2017–2018 fiscal year were not delivered on schedule (Mpumalanga Department of Public Works, Roads, and Transport, 2018:29). Only 169 of the 245 SIPs that were planned for the fiscal year 2018–2019 were completed. Furthermore, only 39% of the completed SIPs were finished on schedule (Mpumalanga Department of Public Works, Roads, and Transport, 2019:29). 48% of SIPs weren’t delivered on time in the 2019–2020 fiscal year (Mpumalanga Department of Public Works, Roads, and Transport, 2020:27). In the province of Limpopo, only 51 out of 86 planned SIPs were implemented during the 2016–2017 fiscal year. De- lays in the planning and procurement processes contributed to some of the poor delivery of SIPs (Limpopo Department of Public Works, Roads, and Infrastructure, 2017:67). In the 2018–2019 fiscal year, the SIPs in Limpopo province experienced slow progress throughout the financial year (Limpopo Department of Public Works, Roads, and Infrastructure, 2019:59). The afore-mentioned statistics on SIPs delivery in Limpopo and Mpumalanga provinces paints a grim picture. This information is supported by the sentiments of Shivambu and Thwala (2009: 902), who indicated that construction projects for the public sector are poorly delivered. Additionally, it has been suggested that poor construction project delivery interrupts economic activities due to a lack of income (Hussein and Omar, 2011:30). Research by Mahamid, Bru- land, and Dmaid (2012:300) found that poor delivery of construction projects is regarded as a common challenge caused by poor management of the four project constraints, i.e., health and safety (H&S), time, cost, and quality. The project constraints are very important since they are a criterion for determining the project’s success. Even financially feasible projects often have cost overruns as a result of time overruns (Samarghandi et al., 2016:52). The Mpumalanga Department of Public Works, Roads, and Transport (2019:31) lists additional factors that contribute to poor SIP delivery, including project cancellations by client departments, community disruptions, community rejection of the scope of works, delays in the selection of suitable sites, delays in the procurement system, poor performance by contractors, and client payment delays. Additionally, small and medium-sized construction enterprises (SMEs) are responsible for the majority of SIPs. However, these SMEs in Limpopo province are not financially sustainable, lack technical skills and entrepreneurial abilities, and are therefore unable to deliver SIPs as expected. In addition, the rising cost of construction materials makes it even more difficult for SMEs to deliver SIPs (Limpopo Department of Economic Development, Environment, and Tourism, 2022:10). It is because of this notion and the variation of causes of poor SIP delivery that the study aims to determine the causes of poor SIP delivery in Mpumalanga and Limpopo provinces.

2. LITERATURE REVIEW

2.1. Introduction

There is a growing need for social infrastructure, which is consistent with government efforts to enhance the standard of public education and health care. Improved and expanded social infrastructure in the areas of social development, culture, sports, and recreation (Mpumalanga Department of Public Works, Roads, and...
Transport, 2019:21) is imperative. However, many SIPs in South Africa are not being completed as planned (Shivambu and Thwala, 2019:902). Government service delivery programmes are negatively impacted by poor SIP delivery (Shivambu and Thwala, 2019:907). The gap in the literature suggests that there are contradictory findings about the causes of poor delivery of SIPs in South Africa.

2.2. Causes of poor delivery of SIPs

According to the Mpumalanga Department of Public Works, Roads, and Transport (2019:21), community protests, delays in finding suitable locations for the construction of SIPs, poor performance by subcontractors, delayed payments by clients, community disapproval of the project scope, and challenges in procurement processes are some of the causes of poor delivery of SIPs. Saraf (2013:1341) argues that low productivity, a labour short-age, poor workmanship, and a lack of commitment disrupt a construction site’s workflow and result in delays that result in poor SIP delivery. Addition- ally, it was found by Shivambu and Thwala (2019:907; Oshungade and Kruger, 2017:18) that subcontractors’ incompetence, the employer’s late payment, and sociopolitical factors such as community disruptions are some of the primary causes of poor SIP delivery. The causes of poor delivery of SIPs in South Africa are discussed herein:

2.3. Socio-economic factors

Socio-political factors such as community uprisings, for instance boycotts and strikes, are the common causes of poor delivery of SIPs (Shivambu and Socio-political factors such as community uprisings, for instance, boycotts and strikes, are the common causes of poor delivery of SIPs (Shivambu and Thwala, 2019:907; Oshungade and Kruger, 2017:18). Sociopolitical factors contribute to the formation of civil rights groups and local business forums, which are usually active in the vicinity of SIPs (Aiyetan, Smallwood, and Shakantu, 2011:24). In the provinces of Mpumalanga and Limpopo, local business forums tend to disrupt construction sites. By preventing construction companies from working until their demands are met. These business forums coercively demand subcontracts worth 30% of the contract value (Mail and Guardian, 2019). The other prevalent socioeconomic challenge is posed by civil rights groups within communities. Typically, the local civil rights groups, through their representatives, would demand an unreasonable number of locals be employed on the SIPs. If they cannot reach an agreement with the main contractor regarding the number of locals to be employed, they resort to protests and boycotts of the construction sites (Oshungade and Kruger, 2017:18).

Community leaders in South Africa play a significant role in assisting political leaders win public support during elections. As a result, politicians often ignore the community leaders’ interference in the projects, which leads to poor SIP delivery. The majority of project stakeholders, including the client, consultants, and contractors, see community discontent as one of the biggest challenges they face while delivering SIPs, according to Mashwama, Mushatu, and Aigbavboa (2018:352). Most often, they happen as a result of strikes, interference by local business forums or council members, delays brought on by negotiations to address issues of concern to the community, or even the abandonment of project sites (Mashwama, Thwala, and Aigbavboa, 2018:1632).

2.4. Poor budget planning

Poor budget planning leads to cost overruns and ultimately poor delivery of SIPs. For example, poor planning for multi-year budget spending projections might stall a project once it has overlapped with the next financial year, and that may lead to the temporary suspension of the construction works by the employer (Oshungade and Kruger, 2017:23–24). One of the main problems affecting the construction industry, particularly small and medium-sized contractors, is delayed payments (CIDB, 2016:28). Only 40% of contractors were paid on time in Mpumalanga province during the period of 2013–2015 (CIDB, 2016:28). Poor delivery of SIPs is caused by an inadequate project control system, poor planning, and an inadequate work definition of scope.
2.5. **Discrepancies in the bills of quantities and design drawings**

Working under time constraints without sufficient coordination between the design team and the quantity surveyor often results in a bill of quantities that contrasts with the design drawings (Oshungade and Kruger, 2017: 22–23). According to Gunduz and Almuajebh (2019:11), design flaws are one of the causes of project delays, impacting the delivery of SIPs.

2.6. **Variation orders**

Building projects often include variation orders, making it almost impossible to complete a project without revising the original scope of work or the building technique used (Oyewobi et al., 2015:141). Variation orders can occur in a construction project for a variety of reasons, including design errors, design modifications, scope creep, incorrect interpretation of contract terms, an un-clear client brief, and discrepancies resulting from improper team coordination (Oyewobi et al., 2015: 142). These are mostly brought about by a lack of coordination amongst the project’s stakeholders (Oyewobi et al., 2015:142). Oshungade and Kruger (2017: 22–23) claim that variation orders have cost variances and lead to scope expansion when new items or activities are added. This may result in extra working days and, ultimately, a project delay, which could impact how effectively SIPs are delivered. Due to the lengthy procedure involved from the time an application is submitted until it is approved by the relevant committee, variation orders may significantly lengthen the timeframe of a project (Oshungade and Kruger, 2017: 22–23).

3. **RESEARCH METHODOLOGY**

The study assessed the causes of poor delivery of SIPs in Mpumalanga and Limpopo provinces. This study adopted the quantitative method, and a survey research strategy was utilized. The survey was implemented by administering a questionnaire to a population sample (Saunders, Lewis, and Thornhill, 2009:144). The questionnaire was split into two sections: Section 1 was to determine the demographics; Section 2 was to determine the causes of poor delivery of SIPs in Limpopo and Mpumalanga provinces.

The participants were asked to select only one answer for each question in Section 1. In Section 2, they had to evaluate statements using a 5-point Likert scale and select one answer per statement according to their experience in SIP delivery. The number of respondents that were surveyed was 103. The researcher used simple random sampling technique to determine the respondents. To achieve the sample size, a margin of error of 5% was used. Therefore, a 95% confidence interval (CI) was used (Gilliland and Melfi, 2010:1). To guarantee that the sample variance is an unbiased estimate of the population variance, the researcher used the N-1 term instead of the N term. The sample size was 124 and the response was 103 respondents. The data was obtained from consultants, contractors, client representatives, and other construction workers who have worked on SIP in the last 6 years, starting in 2021. The data was analysed using descriptive and inferential statistics. The statistical package for social sciences (SPSS) version 28 was used to analyse the data. In analysing the data gathered, information on the respondent’s background was analysed using percent-age, while the causes of poor delivery of SIPs were determined using a mean score of 3 as the mid-point and the t-test to establish the significance of the mean value. These parameters were supported by validity and reliability tests. Reliability and validity of the study were achieved through internal consistency, content validity, and construct validity methods. Cronbach’s
alpha was used to test the internal consistency of the factors measuring the causes of poor delivery of SIPs. Exploratory factor analysis (EFA) was used to establish construct validity.

4. FINDINGS AND DISCUSSIONS

4.1 Demographic background

The results of the demographic data established that 103 participants responded: 36% (n = 37) were consultants, 25% (n = 26) were contractors, 23% (n = 24) were client representatives, and 16% (n = 16) were other construction workers, which included construction supervisors and site foremen. Regarding professional registration, 57 respondents (56%) working in SIPs are not registered. Professional quantity surveyors account for 17 respondents (17%), professional construction managers account for 14 respondents (14%), professional architects account for 8%, and professional engineers account for 6%.

The results revealed that the respondents who hold university degrees and postgraduate degrees have the highest frequencies of 39 and 32 respondents (i.e., 38 and 31%), respectively. This indicates that the majority of the respondents have university degrees, followed by national diplomas with 27 respondents (i.e., 26%), matriculation certificates with 4 respondents (i.e., 4%), and other certificates, i.e., trade certificates, with 1 respondent (i.e., 1%). In terms of formal job experience in SIPs, the results indicate that the majority of those who participated in this research are experienced. There are 36 individuals (38%) who have more than 11 years of formal work experience. Followed by 23 respondents (i.e., 24%) with more than 6 years of formal work experience, 13 respondents (i.e., 14%) with more than 3 years of formal work experience, 11 respondents (i.e., 12%) with 1-2 years of formal work experience, and 12 respondents (i.e., 13%) with less than one year of formal work experience in the SIPs.

4.2 Validity and reliability of data

Construct validity using exploratory factor analysis (EFA) was used to ascertain certain factor loadings of the construct that used a 5-point Likert scale.

Yong and Pearce (2013:81) proclaims that when it comes to factor loading, a value higher than 0.30 suggests a greater contribution to the construct being analysed. Therefore, the cut-off value for factor loading adopted for this study should be equal to or greater than 0.30. Furthermore, Cronbach's alpha was used to determine the internal consistency of the survey instrument. Sürüşçu and Maslaçi (2020:2714) declares that the acceptable range for Cronbach alpha which is the acceptable internal consistency of the scale is 60% and above. However, the Cronbach alpha for the causes of poor delivery of SIPs was 0.521. The results suggest it was below the 60% range, indicating weak internal consistency. However, since the statements were derived from the literature, they could not be eliminated but aligned to the techniques of data analysis, in which precision would not be a concern. These factors were not used as predictor variables. Instead, they would be used to summarize the perceptions of responses of the participants. The Cronbach's alpha was computed using the statistical package for social sciences (SPSS) version 28. The scale was valid and reliable.

4.3 EFA for causes of poor delivery of SIPs

The EFA for causes of poor delivery of SIPs in Table i established a three-factor model. Extraction method applied was principal component analysis. Rotation method used was varimax with Kaiser normalization. Table ii shows the eigenvalues for factors 1 (1.825), 2 (1.157), and 3 (1.040) are greater than 1. These three components explain a total of 67.04% of the variance and were further retained for further investigation. Table i indicate the factor loadings for causes of poor delivery of SIPs: CP1-community protests derail SIPs from achieving their targets, CP2: Closure of construction sites due to lack of funds causes poor delivery of SIPs, CP3-discrepancies in the bills of quantities as compared to design drawings, CP4-variation contributes to scope...
increment, and this can lead to additional working days. CP5-variations prolong the duration of a project due to the long process taken for approval, and CP6-poor budgeting contributes to the poor delivery of a project. As per the results, the causes of poor delivery of SIPs are a three-factor model. The three-factor model was renamed community protests for factor one, lack of funds for factor two, and inaccurate budgeting for factor 3.

Table 1: Factor loadings for causes of poor delivery of SIPs

<table>
<thead>
<tr>
<th>Variables</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP1</td>
<td>0.674</td>
<td>-0.300</td>
<td>0.321</td>
</tr>
<tr>
<td>CP2</td>
<td>0.122</td>
<td>0.001</td>
<td>0.875</td>
</tr>
<tr>
<td>CP3</td>
<td>0.236</td>
<td>0.785</td>
<td>-0.168</td>
</tr>
<tr>
<td>CP4</td>
<td>0.756</td>
<td>0.297</td>
<td>-0.140</td>
</tr>
<tr>
<td>CP5</td>
<td>0.664</td>
<td>0.152</td>
<td>0.110</td>
</tr>
<tr>
<td>CP6</td>
<td>-0.033</td>
<td>0.709</td>
<td>0.487</td>
</tr>
</tbody>
</table>

Table 2: Percentage variance explained causes of poor delivery of SIPs

<table>
<thead>
<tr>
<th>Components</th>
<th>Eigenvalues</th>
<th>% of explained variables</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP1</td>
<td>1.825</td>
<td>30.420</td>
<td>30.420</td>
</tr>
<tr>
<td>CP2</td>
<td>1.157</td>
<td>19.280</td>
<td>49.700</td>
</tr>
<tr>
<td>CP3</td>
<td>1.040</td>
<td>17.341</td>
<td>67.041</td>
</tr>
<tr>
<td>CP4</td>
<td>0.575</td>
<td>12.830</td>
<td>79.652</td>
</tr>
<tr>
<td>CP5</td>
<td>0.550</td>
<td>10.830</td>
<td>90.483</td>
</tr>
<tr>
<td>CP6</td>
<td>0.571</td>
<td>9.517</td>
<td>100.00</td>
</tr>
</tbody>
</table>

4.4 Causes of poor delivery of SIPs in Mpumalanga and Limpopo Provinces.

The results of construct validity and reliability analysis were achieved to enable the t-test to be concluded. The t-test analysis was to determine the difference of the participants’ responses between those who agreed and those who disagreed with the statements and the constructs presented in section.

The t-test and mean value in Table 3 demonstrate that there is substantial evidence to imply that the majority of participants agreed that community protests derail SIPs from achieving their targets (CP1). This is in reference to literature by Oshungade and Kruger (2017:24), as well as Shivambu and Thwala (2019:907), which argued that in South Africa, economic challenges such as boycotts and strikes, as well as sociopolitical factors such as community uprisings, are the main causes of poor SIP delivery. A newspaper article also supported the statement by reporting that the local business forums have a tendency to disrupt construction sites in Mpumalanga and Limpopo provinces (Mail and Guardian, 2019). The newspaper article further states that these business forums violently demand subcontracts worth 30% of the contract amount by preventing construction employees from working until their demands are granted (Mail and Guardian, 2019).

Closure of construction sites due to a lack of funds causes poor delivery of SIPs (CP2). This assertion is supported by literature by Oshungade and Kruger (2017:23–24), which indicates that in South Africa, poor SIP delivery is mostly caused by construction site closures due to a lack of funds. Poor budget planning eventually culminates in cost overruns and poor SIP delivery. For example, poor planning for multiyear budget spending projections might stall a project once it has overlapped with the next financial year, and that may lead to the
CONCLUSIONS AND RECOMMENDATIONS

The findings revealed statistically significant agreement on the causes of poor delivery of social infrastructure projects in Mpumalanga and Limpopo provinces of South Africa. Hence, from the findings, the poor
delivery of SIPs is exacerbated by socio-economic factors, namely: community protests, which may be driven by local business forums; inadequate planning; and a lack of coordination among project stakeholders.

Further, the shutting down of building sites due to a lack of finances negatively affects the delivery of SIPs. Poor budget planning leads to cost over-runs and ultimately poor delivery of SIPs. Despite poor budgeting, errors between bills of quantities and design drawings are also the root cause of poor SIP delivery. Variation orders can contribute to scope increments, and this can lead to additional working days, which causes poor delivery of SIPs. This research has revealed that there is substantial evidence that the participants agreed that the challenges discussed herein are the causes of poor delivery of SIPs. It is therefore recommended that these provincial governments establish mechanisms to curtail these challenges in order to improve the delivery of SIPs.

However, the findings cannot be generalised as the study was limited to two provinces in South Africa. Therefore, the author(s) advocate for a comparative study of all the provisional governments in South Africa to establish if these challenges are unique or similar to all of them.

6. REFERENCES


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roads, and transport.
Assessing the Efficacy of Capital Financing Strategies utilised by Small and Medium-sized Contractors in Windhoek, Namibia

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ABSTRACT

Purpose of this paper
This study sought to assess the efficacy of financing strategies employed by small and medium-sized contractors (SMCs) in Windhoek in terms of accessibility, affordability, and adequacy in a bid to meet their business needs, which in turn catalyses such enterprises’ sustainability.

Design/methodology/approach
The study adopted a qualitative approach which comprised semi-structured interviews with twenty-two (22) purposively selected owner-managers of small and medium-sized contracting firms based in Windhoek. Data were analysed using thematic and frequency analysis.

Findings
The findings revealed nine (9) financing strategies employed by SMCs, with top four (4) being personal savings (100%), bank loan (50%), payments from clients (36%) and suppliers’ credit facility (32%). Each of these financing strategies was observed to be deficient in meeting SMC needs in either accessibility, affordability, or adequacy. Also, the hybrid approach involving both internal and external financing options employed by most SMCs was observed to have yielded little success. Thus, the study concluded that financing strategies employed by SMCs in Windhoek are unsustainable, hence require a thorough review by policymakers, government, and financial institutions.

Research limitations/implications
The qualitative approach, small sample size and geographical delimitation employed precludes the study from being generalised to other settings without caution.

Practical implications
The findings of the current study could assist government, policymakers, financial institutions, and other relevant stakeholders to formulate and implement financing strategies that could curb financial challenges facing SMCs in Windhoek and similar contexts, in a bid to improve such enterprises’ operational capacity and sustainability.

Originality/value of paper.
There is paucity of literature on the efficacy of financing strategies used by SMCs in the Namibian context. Hence, the study findings could be employed to develop financing strategies that enhance accessibility, affordability and adequacy of finance required by SMCs within the context.

Keywords: Efficacy, SMC financing strategy, Accessible finance, Affordable finance, Adequate finance, SMCs, Namibia
1. **INTRODUCTION**

Capital finance is one of the predominant factors required to spur the development and growth of small and medium-sized contractors (SMCs) worldwide (Hove, 2016; ASEAN, 2018; OECD, 2019; Ofefi, Kissi and Nani, 2019). However, the lack of adequate and affordable capital finance remains a bane hampering the sustainability of these enterprises in most developing countries (Mafimidiwo and Iyagba, 2016; Anugwo and Shakantu, 2020; Dhliwayo, Musonda and Gumbo, 2022b).

A plethora of studies advance that, the provision of adequate and affordable capital financing to SMCs curbs a greater proportion of their growth challenges (Domeher, Musah and Hassan, 2017; Perera and Dewagoda, 2020). This stems from the fact that SMCs struggle to raise start-up capital, performance guarantee and insurance policies which are critical in catalysing the successful delivery of their projects (Lello and Mtendamema, 2018; Bikitsa and Amoah, 2022). Notably, site mobilisation alone requires a significant amount of money prior to the actual execution of work on site (Hove, 2016). As a result, this puts SMCs in a precarious position since the construction sector is capital intensive relative to other economic sectors (Ofori, 2015; Tayeh, Alaloul and Muhaisen, 2019; Dhliwayo, Musonda and Gumbo, 2022a). For instance, previous studies on the challenges faced by SMCs in Swaziland (Thwala and Mvubu, 2009), South Africa (Martin and Root, 2012) and Ghana (Eyiah and Cook, 2010) point out that the growth of most SMCs is persistently thwarted by insufficient financing. Similarly, the phenomenon seems to characterise the Namibian context considering its weak financial sector infrastructure as noted by Mukata and Swanepoel (2017). Thus, the efficacy of the previous and current financing strategies employed by various SMCs in most developing countries remains questionable.

Therefore, the paper discusses the efficacy of the capital financing strategies employed by SMCs in Namibia. Critical questions to be answered in the paper include (1) what are the major sources of finance employed by SMCs in financing their operations? (2) How impactful are the sources of finance used by SMCs in meeting their business needs? The paper starts by contextualising SMCs. It goes on to review the SMC financing strategies and the extent to which the adopted strategies addressed SMCs’ needs. Thereafter, the paper describes the methodology, results, and discussion. It then ends by highlighting the conclusion and recommendations.

2. **LITERATURE REVIEW**

2.1 Contextualising SMCs

There is no unanimity among scholars regarding the definition of SMC, as it varies with context (Dar, Ahmed and Raziq, 2017; Lello and Mtendamema, 2018; Bikitsa and Amoah, 2022). However, the cited scholars clearly demonstrate that the criteria commonly employed in defining SMC include the number of employees, capital outlay, income turnover, and physical assets. Aigbavboa and Thwala (2014) argue that SMCs are relatively small in size and possess limited funds as well as being weak in structure. This is evident in the Namibian context where SMC is viewed as an enterprise with full-time employees ranging from 11 to 100, and an annual turnover spanning from N$300 001 to N$10 000 000 (MSME Policy Namibia, 2016). As such, the characteristics of SMCs seem to directly influence the financing options that SMCs can pursue to finance their projects (Hove, 2016; Domeher, Musah and Hassan, 2017).

2.2 SMC Financing Strategies

Extant literature highlights numerous financing strategies employed by SMCs in various developing countries to support their activities (Anamege, 2019; Ali et al., 2020; Ganlin et al., 2021). The role of government has been reportedly pivotal in easing the financial pressures faced by SMC (Hove, 2016; Amoah and Bikitsa, 2021; Ganlin et al., 2021). Considering the importance of SMCs in socio-economic development worldwide, Eyiah (2001) points out that most governments in developing countries have introduced SMC financing policies which are categorised into (i) those designed to reduce contractors’ needs for working capital and (ii) those to
enhance their access to loans. As outlined by Eyiah, measures for improving working capital include the relaxation of bond requirements, reduction of retention money, improvement of contract payment procedures and payment of mobilisation. Nonetheless, efforts to promote accessibility of loans from the formal financial market to SMCs have yielded little results thus far (Eyiah, Kheni and Acquah, 2018; Offei, Kissi and Nani, 2019). Generally, the cited scholars argue that financial institutions portray a negative perception towards financing SMCs. As a result, the financial strategy used by an individual SMC appears to depend on a myriad of factors which include the SMC’s needs, its internal liquidity, and its ability to access external financing.

In Ghana, Domeher, Musah and Hassan (2017) observed that SMCs at the startup phase largely rely on personal savings and funds from friends and families to finance their projects. Precisely, during infancy phase, SMCs reportedly lack the track record and collateral that are precursor to access external funding (Hove, 2016; Taiwo, Falohun and Agwu, 2016). In fact, at the early phases of their establishment, SMCs are viewed by financiers as high risk, which in turn leads to the reluctance by financiers to support such enterprises (Ali et al., 2020). It is noteworthy to mention that the Ghanaian government made concerted efforts as far back as the 1990s to financially capacitate SMCs (Eyiah, 2001, 2003; Eyiah and Cook, 2010). As Eyiah (2003) presents, one such strategies was the introduction of banks such as the Bank for Housing and Construction (BHC) which concentrated on providing plant and equipment to SMCs. Despite these efforts, Eyiah and Cook (2003) report that BHC’s support towards SMCs was frustrated by default in loan repayment by most beneficiaries. Consequently, it is reported that BHC tightened its lending conditions by demanding collateral from SMCs which subsequently limited their accessibility to financial support (Eyiah and Cook, 2003). This was further exacerbated by the fact that most formal financial institutions offer credit rationing coupled with stringent conditions such as high interest rates and short loan amortisation period to curb the perceived risks related to SMCs (Domeher, Musah and Hassan, 2017). As such, SMCs in Ghana continue to face liquidity challenges. Notably, the personal savings which they largely rely on are inadequate to finance their operations (Domeher, Musah and Hassan, 2017; Eyiah, Kheni and Acquah, 2018; Anamege, 2019).

Similarly, in Nigeria, the government introduced numerous strategies over the past six (6) decades to improve financial accessibility by small businesses (Gbani and Amissah, 2014; Ovat, 2016; Rogo, Mohd-Shariff and Hafeez, 2017). These strategies include the establishment of Rural Banking Policy between 1977 to 1980, Bank of Industry (BOI) in 2002, Micro Finance Banks in 2007 and Small and Medium Industries’ Equity Investment Scheme (SMIEIS) around 2001. Furthermore, Duke and John (2010) note that the Nigerian government introduced a tax relief to startups for the first 6 months to boost their cashflow. Additionally, the Nigerian government has also made advance payments to some SMCs in a bid to boost their cashflow (Aje and Adedokun, 2018). Hussin and Omran (2009, p.239) define advance payments as “advances of money by the client of any project to a prime contractor before, in anticipation of and for the purpose of complete performance under one or more projects”. According to Aje, Olatunji and Olalusi (2016), advance payment is given to contractors and subcontractors to improve their cashflow, especially at the beginning of the project. In other words, advance payment is capital injection which is meant to assist the SMC to mobilise resources. This strategy is also common in Sri Lanka, where the government employs it to stimulate SMCs’ performance (Hashan, Waidyasekara and Sirimewan, 2021). Also, the Ghanaian government used to provide advance payments to SMCs in the late 1990s (Eyiah and Cook, 2003). As advanced by Aje and Adedokun, advance payment has a positive and significant effect on contractors’ net cash flows including cost and time performance of projects. In Malaysia, Husin and Omran observed that advance payment assisted beneficiary contractors to speed up projects, hence saved on completion time. On the other hand, advance payment is believed to curb price fluctuations on materials and labour (Aje, Olatunji and Olalusi, 2016). Also, considering that this financing option is interest free, it assists in mitigating cost overruns and costly delays as alluded to by the cited scholars. Moreover, where advance payment was employed, SMCs did not need to source out external funding which is...
not only challenging to obtain but also expensive to service compared to advance payment.

However, the amortisation of advance payment was seen as problematic among SMCs in most countries (Eyiah and Cook, 2003; Aje, Olatunji and Olalusi, 2016). In Ghana, SMCs who were advanced by the Ghanaian government allegedly diverted the funds for personal use at the detriment of projects (Eyiah and Cook, 2003; Asante, Kissi and Badu, 2017). Hence, the Ghanaian government ended up stopping to advance SMCs. This appears to be the same disappointment experienced in most developing countries where efforts to catalyse SMCs through advancement payments were made.

Therefore, while the mentioned efforts were observably noble in the quest to support SMCs in the mentioned countries, it is paramount to highlight that most strategies did not ameliorate the financial quagmire related to SMCs. As pointed out by Gbandi and Amissah regarding the Nigerian context, it is noteworthy to highlight that despite several strategies introduced by the Nigerian government, most banks fostered profitability as opposed to supporting SMCs which they viewed as bad investment. Understandably, commercial banks are persistently defiant to the increasing call to support SMCs, due to the perceived risks tagged to these contractors (Gbandi and Amissah, 2014; Taiwo, Falohun and Agwu, 2016). In fact, Taiwo, Falohun and Agwu reveal that 96.4 percent of Nigerian SMCs continue to use personal savings, while the formal financial market contributes a pantry of 0.21 percent, with the remainder being obtained from the informal market. As a result, the SMC financing challenge remains incessant regardless of the numerous efforts made over the years by the Nigerian government. This situation also mirror the picture in most countries in Southern Africa which include the Kingdom of Eswatini (Thwala and Mvubu, 2008, 2009) and South Africa (Hove, 2016; Anugwo and Shakantu, 2020) where most banks have displayed the reluctance to finance SMCs. Like in most developing countries, Thwala and Mvubu contend that banks in Eswatini only support SMCs that afford the required high interest rates and collateral security. The same depicts the South African context where Hove noted that high interest rates and the need for collateral security characterise most banks in the country. This leaves the majority of SMCs in most developing countries grappling with financial constraints, since personal savings which are commonly used are unsustainable.

To improve the financial situation facing SMCs, several strategies were suggested in existing literature which include a dedicated financial institution, unlimited access to debt finance, low interest rate, removal of collateral security, long term repayment period, advance payment, relax retention and performance guarantee provision, and prompt payments by clients as elaborated in succeeding sections as summarised on Table 1.

Table 1: Strategies to improve SMC capital financing

<table>
<thead>
<tr>
<th>Strategy</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated Financial Institution for SMCs</td>
<td>Gbandi and Amissah, 2014; Domeher, Musah and Hassan, 2017; Eyiah, Kheni and Acquah, 2018</td>
</tr>
<tr>
<td>Unlimited access to debt finance</td>
<td>Martin and Root, 2012; Imafidon and Iloya, 2014; Taiwo, Falohun and Agwu, 2016</td>
</tr>
<tr>
<td>Low cost of capital</td>
<td>Hove, 2016; Tayeh, Alaloul and Muhaisen, 2019; Ali et al., 2020</td>
</tr>
<tr>
<td>Removal of Collateral Security</td>
<td>Offei, Kissi and Nani, 2019; Anugwo and Shakantu, 2020; Balogun and Ansary, 2017</td>
</tr>
<tr>
<td>Advance Payment</td>
<td>Aje, Olatunji and Olamusi, 2016; Aje and Adedokun, 2018; Hashan, Waidyasekara and Sirimewan, 2021</td>
</tr>
<tr>
<td>Waiving retention and performance guarantee requirements</td>
<td>Kendig, 2011; Ugochukwu and Onyekwena, 2014</td>
</tr>
</tbody>
</table>
However, even though most of the tabulated strategies are sound, their practical implementation has remained problematic over the years. Thus, the understanding of the efficacy of the strategies used in a particular context like Namibia could assist in formulating the financing strategies that are more appropriate to SMCs in a bid to catalyse their development and sustainability.

3. METHODOLOGY
The current study collected data from twenty-two (22) purposively selected owner-managers of small and medium-sized contracting firms based in Windhoek. A semi-structured interview guide was employed to gather data on the financing strategies used by SMCs in Windhoek as well as probing the accessibility, affordability, and adequacy of such strategies in financing their businesses. Windhoek is the commercial centre and capital of Namibia, thus over 80% of the SMCs are headquartered in this city. Therefore, the findings based on Windhoek largely reflect the Namibian construction industry. The interviews were one on one, with some conducted face to face, while others were done telephonically and through Zoom meetings. The interview protocol involved a brief explanation of the aim of the study, request for the participant’s consent and a pledge by the researcher to comply with ethical issues. Additionally, a soft copy document of informed consent form was emailed to each participant prior to interviews. To protect the identity of participants, a coding system was employed to conceal the identity of participants using P1 to P22. Each interview session took an average of 10 minutes. The data collected through face to face and telephonic interviews were recorded using Smart Phone-Galaxy A10S, while Zoom interviews were recorded on the laptop. Recorded data were then downloaded and saved in one folder in the laptop and transcribed. Thereafter, the study checked transcripts for accuracy, and then analysed using thematic and frequency analysis.

4. RESULTS AND DISCUSSION
Data collected from the interviews is summarised in Table 2. Thus, table 2 shows participants’ responses related to financing strategies utilised by SMCs in Windhoek, as well as the efficacy of each identified strategy as measured by there parameters namely accessibility, affordability, and adequacy of the financing strategy in meeting SMC’s business needs.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Financing Strategy(s)</th>
<th>Efficacy</th>
<th>Accessibility</th>
<th>Affordability</th>
<th>Adequacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Own money</td>
<td>Easily accessible</td>
<td>No interest-Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Payments from clients</td>
<td>Delayed payments-Not always accessible</td>
<td>No interest-Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Source of Finance</td>
<td>Access</td>
<td>Interest</td>
<td>Affordability</td>
<td>Additional Conditions</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td>----------</td>
<td>---------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>Retailed profits</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Suppliers’ credit facilities</td>
<td>Difficult</td>
<td>Stringent</td>
<td>conditions required</td>
<td>No interest</td>
<td>Affordable</td>
</tr>
<tr>
<td>Bank loan</td>
<td>Difficult</td>
<td>Stringent</td>
<td>conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rationing</td>
</tr>
<tr>
<td><strong>P2</strong> Personal savings</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Payments from clients</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Bank loan</td>
<td>Difficult</td>
<td>Stringent</td>
<td>conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rationing</td>
</tr>
<tr>
<td><strong>P3</strong> Own money</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Inadequate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payments from clients</td>
<td>Delayed payments, hence moderately accessible</td>
<td>High interest, require collateral</td>
<td>Credit rationing</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Bank loan</td>
<td>Difficult</td>
<td>Stringent</td>
<td>conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rationing</td>
</tr>
<tr>
<td><strong>P4</strong> Personal funds</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Suppliers’ credit facility</td>
<td>Demand</td>
<td>bank guarantee-hence difficult to access</td>
<td>No interest</td>
<td>Affordable</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Payments from clients</td>
<td>Somehow accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td><strong>P5</strong> Own resources</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Inadequate</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td>Payments from clients</td>
<td>Delayed payments- Not always accessible</td>
<td>High interest, require collateral</td>
<td>Credit rationing</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td><strong>P6</strong> Own money</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td>Bank loan</td>
<td>Difficult</td>
<td>Stringent</td>
<td>conditions required</td>
<td>High interest, require collateral</td>
<td>Low Threshold</td>
</tr>
<tr>
<td><strong>P7</strong> Personal funds</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td><strong>P8</strong> Personal funds</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td>Bank loan</td>
<td>Difficult</td>
<td>Stringent</td>
<td>conditions required</td>
<td>High interest, require collateral</td>
<td>Low Threshold</td>
</tr>
<tr>
<td><strong>P9</strong> Personal savings</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td>Bank loan</td>
<td>Difficult</td>
<td>Stringent</td>
<td>conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rating</td>
</tr>
<tr>
<td><strong>P10</strong> Own money</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td><strong>P11</strong> Own savings</td>
<td>Easily accessible</td>
<td>No interest</td>
<td>Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td>Page 12</td>
<td>Own savings</td>
<td>Easily accessible</td>
<td>No interest/Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>--------------</td>
<td>-------------------</td>
<td>------------------------</td>
<td>---------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suppliers' credit facility</td>
<td>Easily accessible</td>
<td>No interest/Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank loan</td>
<td>Difficult-Stringent conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rating-inadequate</td>
<td></td>
</tr>
<tr>
<td>Page 13</td>
<td>Bank loans</td>
<td>Difficult-Stringent conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rating-inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suppliers' credit facility</td>
<td>Require track record - hence difficult to access</td>
<td>No interest/Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Page 14</td>
<td>Suppliers' credit facility</td>
<td>Need to build prior relationships - hence difficult to access</td>
<td>No interest/Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Own savings</td>
<td>Easily accessible</td>
<td>No interest/Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank loan</td>
<td>Difficult-Stringent conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rating-inadequate</td>
<td></td>
</tr>
<tr>
<td>Page 15</td>
<td>Own savings</td>
<td>Easily accessible</td>
<td>No stringent conditions-Affordable</td>
<td>Insufficient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suppliers' credit facility</td>
<td>It's conditional - Not always accessible</td>
<td>No interest/Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank loan</td>
<td>Difficult-Stringent conditions required</td>
<td>High interest, require collateral</td>
<td>Credit rating-inadequate</td>
<td></td>
</tr>
<tr>
<td>Page 16</td>
<td>Personal resources</td>
<td>Easily accessible</td>
<td>No stringent conditions-Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Page 17</td>
<td>Own savings</td>
<td>Easily accessible</td>
<td>No stringent conditions-Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Friends' support</td>
<td>It's conditional - Not always accessible</td>
<td>Negotiated interest rate and payment terms</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Family support</td>
<td>Easily accessible</td>
<td>No stringent conditions-Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Page 18</td>
<td>Own money</td>
<td>Easily accessible</td>
<td>No stringent conditions-Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Payments from clients</td>
<td>Delayed payments - Not always accessible</td>
<td>No interest/Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td>Page 19</td>
<td>Personal savings</td>
<td>Easily accessible</td>
<td>No stringent conditions-Affordable</td>
<td>Inadequate</td>
<td></td>
</tr>
</tbody>
</table>
4.1 SMC Financing Strategies

The financing strategies mentioned by the interviewed owner-managers of contracting firms in Windhoek include personal savings or own money, bank loan, payments from clients, suppliers’ credit facility, funds from friends, financial support from family members, funds from microfinance and contributions from business partners. Table 2 shows the financing strategies employed, ranked based on frequency analysis.

Table 2: SMC Financing Strategies

<table>
<thead>
<tr>
<th>Financing Strategy</th>
<th>Participants</th>
<th>Percentage Frequency</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal savings or own money</td>
<td>All</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Bank loan</td>
<td>P1, P2, P3, P6, P8, P9, P11, P12, P13, P14, P15</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Payments from clients</td>
<td>P1, P2, P3, P4, P5, P18, P20, P22</td>
<td>36%</td>
<td>3</td>
</tr>
<tr>
<td>Suppliers’ credit facility</td>
<td>P1, P4, P12, P13, P14, P15, P20</td>
<td>32%</td>
<td>4</td>
</tr>
<tr>
<td>Funds from friends</td>
<td>P17, P22</td>
<td>9%</td>
<td>5</td>
</tr>
</tbody>
</table>
4.1.1 Personal Savings

All the owner-managers mentioned that most of their projects are funded through personal savings due to the difficulties in accessing external funding. For instance, P1 said:

“We depend on our personal savings to fund our projects because it’s not easy to access loans from banks”. [P1]

Likewise, P2 concurred with P1 by saying:

“Our projects are mainly funded from own money. It is difficult to get money from these commercial banks”. [P2]

These sentiments resonated with all the other 20 owner-managers interviewed.

Therefore, the observations made in this study align with extant literature from other developing countries (Hove, 2016; Domeher, Musah and Hassan, 2017; Anamege, 2019) which reveals that personal savings are commonly employed by SMCs to finance their projects due to these enterprises’ inability to secure external funding. Domeher et al. further argue that, even though personal savings are interest free, they are usually insufficient to finance SMC operations due to the nature of the construction business which is capital intensive.

4.1.2 Bank Loans

Bank loan is one of the strategies cited by eleven (50%) of the participants as used in financing SMC activities in Namibia. P2 highlighted that the firm often engages the bank for startup capital, especially on large projects since personal savings would be insufficient to mobilise resources.

“For large projects, we often approach Development Bank of Namibia (DBN) for assistance”. [P2]

However, P2 pointed out that the requirements from the bank are unfriendly and sometimes unattainable since most SMCs lack of track record and collateral.

Likewise, P3 shared that whenever bank finances an SMC, the credit is rationed, hence inadequate to finance construction activities. This position was advanced by other participants (P6, P8, P9, P11, P12, P13, P14, P15) who mentioned that most banks view SMCs as high risk, thus put a ceiling.

The findings are consistent with existing literature related to bank financing (Gbandi and Amissah, 2014; Imafidon and Itoya, 2014; Ovat, 2016; Taiwo, Falohun and Agwu, 2016; Domeher, Musah and Hassan, 2017). Ovat posit that commercial banks are focused on profitmaking, hence view SMCs as bad investment. This is corroborated by Taiwo, Falohun and Agwu who observed that banks in Nigeria contribute less than 1 percent to SMCs despite incessant call for them to support these enterprises. In fact, Taiwo et al. noted that 96.4 percent
of Nigerian SMCs continue to use personal savings.

4.1.3 Payments from clients
Interim payments received during construction have also been noted as a strategy used by several SMCs to finance running projects (P1, P2, P3, P4, P5, P18, P20, P22). P4 said:

“Payments from clients are critical in financing ongoing construction activities. These have been helpful, of which without them, construction work would stop.” [P4]

In support, P18 shared that:

“You can’t do any meaningful progress without prompt payment for work done. Banks are unreliable, hence payment for work done has been our main source since we are small.” [P18]

However, participants echoed the delayed payments as a bane on most government projects, thus stifling their cashflow to successfully run their projects.

Therefore, the findings related to the importance of payment for work done and the rampant delays which makes dependence on payments to run projects resonate with several scholars (Tayeh, Alaloul and Muhaisen, 2019; Xie et al., 2019; Perera and Dewagoda, 2020; Ganlin et al., 2021). Perera and Dewagoda (2021, p.236) claim that “payments are the lifeblood of construction projects. Also, Aje, Olatunji and Olalusi (2016) assert that efficient payment mechanisms stimulate performance on projects.

4.1.4 Suppliers’ credit facility
Some participants (P1, P4, P12, P13, P14, P15, P20) have cited the use of suppliers’ credit facilities to finance their projects instead of going to banks etcetera. The advantage of credit facilities is that the SMC can secure construction materials and or plant and equipment without upfront payment, and start running the project, then pay the creditor later. For instance, P1 said:

“We have a 30-day account at Pupkevitz Hardware Shop which assists us securing major materials on credit.” [P1]

However, all the participants that use credit facilities expressed that the credit facilities do not cover all the costs required to run the project, hence one would have to look for further support elsewhere to augment this, to successfully run the project(s). Moreover, it was noted by some participants that credit facilities are not always accessible because they are provided based on trust or confirmed track record. Therefore, 66% of the participants mentioned that they could not use credit facilities because suppliers were reluctant to provide such services to them due to information asymmetry and perceived risks associated with SMCs.

4.1.5 Other strategies (Funds from friends, family members, microfinance institutions, retained profits and partnerships)
Few of the participants indicated that they often rely on funds from friends (P17, P22), family members (P17), microfinance institutions (P20), retained profits (P1) and partnerships (P21). However, funds from friends, family members and partnerships were reportedly inadequate to finance construction projects, even though they can be easily accessible at negotiated or zero interest charge. On the other hand, funds borrowed from microfinance have been reported to be of low threshold coupled with exorbitant interest rates and short payment
period which make them unsustainable to finance SMC construction activities. In addition, retained profits were highlighted by P1 as a good injection for the growth of the SMC business. However, retained profits were observed as contributory but not solely a panacea to the financial demands of running SMCs projects which are usually capital intensive.

Therefore, to mitigate the limitations posed by a single financing option, the study observed that most SMCs use a combination of 2 or more financial strategies. For instance, P1 employed a combination of personal savings, payments from clients, retained profits, suppliers’ credit facilities and bank loans. Only 4 participants coded P7, P10, P16 and P19 claimed to have used a single financing strategy (personal savings) to finance their projects, of which this has been previously highlighted as insufficient to fund their projects.

The observed findings are supported by a plethora of studies (Mafimidiwo and Iyagba, 2016; Domeher, Musah and Hassan, 2017; Anamege, 2019). In a study focusing on financing strategy used by SMCs in Nigeria, Anamege observed that funds from friends and family members were part of the options utilised by SMCs albeit their deficiencies. Furthermore, Domeher et al. also point out that personal savings are commonly used at the infancy phase of the SMC. However, as the firm grows, Domeher et al. argue that most SMCs would prefer a hybrid approach which involves both personal funds and external funds. Therefore, this supports the circumstances observed in the Namibian context as presented on Table 1.

5. CONCLUSIONS AND RECOMMENDATIONS

This study sought to assess the efficacy of financing strategies utilised by SMCs in Namibia. Based on the findings from the data collected in Windhoek, it is concluded that the financing strategies commonly used by SMCs in Namibia, in descending order include personal savings, bank loans, payments from clients, suppliers’ credit facility, funds from friends, funds from family members, loans from microfinance, funds from partnerships and retained profits. However, the study observed that each of the identified strategies is either inaccessible, unaffordable, or inadequate to finance SMC operations. For instance, personal savings are easily accessible and affordable but discredited for being insufficient to finance construction activities if not augmented by other options. Also, bank loans are difficult to access due to stringent conditions, high interest rates and credit rationing. Again, payments from clients are expected to be easily accessible since this is a contractual obligation for clients to pay for work done in a bid to improve SMC’s cashflow. However, payment delays have been observed as rampant on most construction sites in Windhoek, hence it is problematic to rely on payments to finance SMC projects. Besides, prior to securing even the first payment, the SMC should have secured funds elsewhere to finance the works, thus interim payments alone would be insufficient to meet SMC financing needs. Also, suppliers’ credit facility was observed as provided to SMCs based on proven track record, hence is not accessible to most startups. Therefore, the study concluded that the financing strategies utilised by SMCs in Windhoek, Namibia are ineffective in terms of accessibility, affordable and adequacy, hence do not meet SMCs’ needs, culminating in the need for a thorough review by all key stakeholders.

Consequently, these findings have potential to inform SMC financing policy. Thus, the study recommends that policymakers, government, financial institutions, and other key stakeholders in Namibia and similar settings adopt the findings in a bid to formulate SMC financing strategies which meet SMCs’ business needs to improve their operations and ultimately, their sustainability.

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ABSTRACT

Purpose
Due to the incongruity of energy demand and supply, and the built environment being the main contributor to global warming through its CO₂ emissions, the adoption of on-site renewable energy production, have been made a priority in South Africa and the world. However, current renewable technologies that are employed are not efficient enough to meet the energy demands of population growth. Artificial Photosynthesis Technology (APT) in building façades is an established renewable energy production technology considered to be an advancement to Solar PV systems in the context of energy production and CO₂ emissions reduction. The paper analyses current practices, potential benefits of implementing AP in building façades and the challenges anticipated.

Design
A quantitative research design was used for the study and the population consisted of respondents chosen from the list given by Green Building Council South Africa (GBCSA) of the professionals using sustainable systems based on convenience sampling. The data collected was analyzed with descriptive statistics.

Findings:
The results indicated the extent of the South African built environment’s satisfaction with the current nature of on-site energy production and its readiness to adopt an advanced technology like AP. The challenges ranked the availability of proper materials to build AP as the most likely factor to impede the successful implementation of this technology and the underutilization of smart building façades in the industry.

Value: The main drivers for the deep transformation needed to make renewable energy the norm, should aim to give flexibility to the grid and policy support to drive cost reductions.

Keywords: Artificial Photosynthesis, Building façades, Carbon Capture, CO₂ emissions, On-site energy Production
INTRODUCTION

The understanding of sustainable development and its connection to the economic, social, and environmental sectors is directed towards preservation and stimulation of financial growth while taking into consideration societal well-being, in addition to the quality of the environment. However, anthropogenic activities resulting in energy consumption in manufacturing, construction and the built environment, transportation and other sectors respectively, have contributed immensely to an increase in greenhouse gas emissions, particularly CO₂, which is regarded as a primary cause of global warming.

Although there are many underlying factors to this, one of them is the rapid increase of human population. According to Statistics South Africa, the South African population is estimated to be approximately 60.14 million. The unbridled population growth has been shown to cause rapid urbanization which in turn has led to increases in energy demands. The unfortunate consequence of this is that the supply of energy is not congruent to the demand of energy. This has created an imbalance between the supply and demand of energy. In 2020, a report from Enerdata showed that only 84.4% of South Africans have access to power. And the reality for both residential and non-residential (commercial, transportation, industrial etc.) activities is, building additional power plants to boost supply has become increasingly expensive. Global concerns relating to the negative contribution of fossil based electricity generation to the environment puts further constraints on the design and construction of any additional power plants.

Global energy is currently being harnessed from fossil fuels, which are the most dependable and practical energy sources due to their energy density, stability and ease of distribution due to the availability of sufficient infrastructure. However, fossil fuels have their own drawbacks as they have a limited supply due to their non-renewability and dreadful impacts on the environment. Existing single-sources in meeting the energy demand no longer appear as feasible propositions thus the drive for energy security, when coal-powered plants are decommissioned. These plant should have replacements that can cover the expected shortfalls due to delays in completion of new plants or other competing factors. Renewable energy should be seen as a complement to meeting the energy demand because a single-source energy system, may not be considered reliable.

The threat posed by the construction industry’s role in the emissions of CO₂ and the limitations of the currently employed renewable energy technologies in the industry, requires a transition towards carbon capture, to promote the renewable energy generation drive, within the country. Carbon capture, however, allows for the continued use of fossil fuels with little CO₂ emissions. This permits the promotion of clean development mechanisms that can feed-in to the grid, by the National Energy Regulator of South Africa (NERSA). Artificial Photosynthesis (AP) offers the construction industry an opportunity to utilize the carbon capture technology to not only reduce the rate at which CO₂ is emitted but to extract the already emitted CO₂ and use it as an input to produce renewable energy through the process of photosynthesis.

The use of building façades as the interface between the external and internal environments of a building plays an integral part of the building design and the use of AP. Façade systems have a large impact on the occupant's interface with the surrounding environment; energy efficiency and the indoor environmental quality performance of a building. As high-performance sustainable enclosures, façades involve selecting and deploying the right materials, advanced technologies, good detailing, and installation, all of which must be contextually and functionally appropriate to absorb greenhouse gas in the atmosphere; to primarily minimize the construction industry’s contribution to CO₂ emissions.

Research shows that façades are not a new concept nor is the thought of greening façades as an energy saving method for the built environment. Most studies of view façades as design strategies used to improve occupants’ comfort by blocking adverse external environmental effects. The cooling effect of green façades has an impact on the building’s inner climate. The introduction of high-performance sustainable façades to post...
a dual effect of reducing building energy consumption and improving indoor thermal comfort, has received much attention in research and development\textsuperscript{13}. This has facilitated an integrated design approach that sees façades as adaptive shading systems which can be used to control solar gains and natural lighting\textsuperscript{14}. Similarly, integrating photovoltaics (PV) opens new opportunities for solar tracking and using AP. The primary goal of this paper is to conduct an explorative study to elicit the perceptions of relevant stakeholders regarding the potential benefits accruable from the implementation AP in building façades as a source of onsite renewable energy generation and simultaneously, engender the reduction of CO\textsubscript{2} emissions in the contemporary built environment.

2. LITERATURE REVIEW INTRODUCTION

South Africa contributes about 42\% of Africa’s carbon emission\textsuperscript{15} due to the nation’s high dependence on coal for power generation\textsuperscript{16}. Accordingly, the increasing electricity demands have led to a rise in CO\textsubscript{2} emission. The imminent solution to the high carbon footprint would be the diversification into renewable energy resources. CO\textsubscript{2} which is one of the greenhouse gases emitted to the atmosphere when fossil fuels are burnt to produce energy has been reputed as contributing to global warming. Excess Also, this gas when emitted, contributes to the inability of plants and oceans to maintain an atmospheric balance between CO\textsubscript{2} and oxygen\textsuperscript{17}. The primary contributor to the emission of CO\textsubscript{2} is the construction industry with its activities ranging from the production of building materials, construction works and the operational phase of buildings\textsuperscript{18}. The exponential growth of the building sector due to the rapid urban population increase, is likely to cause further rise in amount of embodied energy and CO\textsubscript{2} emissions emanating from the built environment and the construction industry. This situation is exacerbated by poor management of building materials which has culminated in increased waste generation on building construction sites\textsuperscript{19}. South Africa is the 12\textsuperscript{th} highest emitter of CO\textsubscript{2} globally and the construction industry independently consuming approximately 36\% of the energy\textsuperscript{20}. Taffese and Abegaz\textsuperscript{21} has categorized energy consumption across a building’s lifecycle into three distinct categories, namely: (i) Initial embodied energy (IEE): Energy consumed in the production process of a product, from the extraction of raw materials and processing of natural resources to the manufacturing and transport of products to building construction sites. It also includes the energy that is directly associated with the construction activities. IEE is thus all the energy that is consumed in the pre-use phase of the building’s lifecycle. (ii) Recurrent embodied energy (REE): Energy required to maintain, repair, and/or refurbish the buildings during their service life. REE is a function of how a building is used by its occupants, the maintenance demands of the occupants, the service life of the building, and the life span and quality of the materials and components. (iii) Demolition embodied energy (DEE): Energy consumed to destroy the building at the end of its lifecycle, recycle and re-use some components, and dispose of others by transporting the debris and waste to landfills or incinerators. DEE is a largely uncertain component of the embodied energy content due to data unavailability issues, and therefore it is difficult to capture.

The need to reduce the emissions of CO\textsubscript{2} by transitioning from fossil fuels to renewable energy sources such as solar and wind while addressing the issue of the incongruency between energy supply and demand is not a foreign concept to South Africa. However, these sources have limitations as they are location-and-weather dependent for optimal performance and the energy produced does not match the demand and there is a constant be fluctuations in the energy produced from these sources\textsuperscript{22} (Das et al., 2019). The global power generating capacity from renewable energy sources from 2012 to 2018 are shown in Figure 1. Solar energy as of 2018 still has the highest focus in terms of power generation with a total investment of $139.7 billion. Next to solar energy in terms of investment, is wind energy at $134.1 billion, waste-to-energy and biomass at $8.7 billion, while others are lagging\textsuperscript{23}.
Large infrastructures that are used as storage facilities for the effective use of these energy sources need to be put in place. This may not be feasible in developing countries like South Africa due to the deteriorating state of the current distribution infrastructure for conventional energy.

**Onsite energy production and CO₂ emissions reduction using APT**

Inspired by natural photosynthesis, researchers like Bonke, Nguyen and Wang have undertaken studies to develop APT that integrate various photocatalysts and biocatalysts to convert and store solar energy in the fields of resource, environment, and energy. To improve the system efficiency and reduce the operation cost, reaction platforms introduced in APT must be addressed to provide better solar energy storage, which will lead to easier access to energy. APT replicates the photochemical process of natural photosynthesis. However, it is more dedicated to the production of useful fuels or valuable chemicals that can enhance energy storage capabilities. The main goal is to create a renewable energy source that is more efficient and cheaper than current energy alternatives. However, there is still a struggle to achieve the energy yields needed to power the modern society and the primary barrier to this, is the efficiency of light capture and conversion into fuel. Today’s most efficient photosynthetic organisms capture around 1% of the solar energy, a fraction of the capturing efficiency of plants and cyanobacteria. Thus, the importance of the ability to adapt light levels for solar energy harvesting and using façades to capture the light-rays.

The field of AP, or photovoltaics (PV), is an energy technology that converts light into electricity. By harvesting light through solar cells, sunlight can be converted into useful electrochemical energy. APT uses the antenna units to harvest sunlight and the excitation energy is funnelled to the reaction centre where a multistep electron-transfer reaction occur to generate potential that can drive chemical reactions to produce chemical energy that can be used to as a cost-effective alternative energy source that can meet human energy demands in an environmentally responsible manner. The major goal of AP is to develop a system that can generate clean, renewable energy in a cost-effective way. This paper focuses on the APT which can generate clean energy whilst allowing reduced daylight harvesting, to minimize energy consumption using façades. Building account for 40% of total primary energy consumption worldwide, and this figure is expected to rise if...
no energy efficiency measures are implemented.

To attain net-zero carbon emissions, the construction sector must adopt sustainable technology and construction practices which will utilize energy-efficient technologies\(^{30}\). Al-Ghamdi and Bilec\(^{31}\) believed that the adoption on-site renewable energy as a sustainable construction method has positive environmental consequences. Their study incorporated photovoltaic technologies in buildings to produce between 20 and 40% of its electricity needs leading to the reduction of CO\(_2\) emissions by approximately 635 000 to 1 347 000 kg. In another study, Al-Ghamdi and Bilec emphasized that solar energy is the most plenteous of all energy sources and can be applied in many ways. The most applicable method is the use of PV cells in façades to capture solar rays. This technology is designed to reduce energy by increasing the daylight penetration within a building while controlling glare\(^{10}\).

Consequently, this proves that onsite solar energy cannot replace conventional electricity in buildings, therefore it is not efficient enough. What the study aims to do; is to assess the perceptions of stakeholders in the energy sector that have knowledge about renewable energy and find out the possibility of applying AP in façades for on-site energy production in buildings; and how this will allow buildings to be self-sufficient in terms of their energy needs. Al-Ghamdi and Bilec\(^{31}\) study is important as it supports the proposition that on-site renewable energy production for buildings will potentially reduce the construction industry’s CO\(_2\) emissions significantly.

**AP in the context of sustainable construction**

While sustainable construction has gained increasing international attention, a limited number of studies address the issue of sustainable construction in South Africa. The adoption and implementation of sustainable solutions in the South African construction industry is also not apparent\(^{32}\). The impact of the unsustainable activities of the construction industry on environmental degradation was put at 15% of freshwater resources, 40% of the world’s energy, and 23%-40% of the world’s greenhouse gas emissions\(^{33}\). Excessive resource and energy use, as well as rising raw material demand, are now primarily responsible for the global depletion of natural resources and global warming.

Global warming poses an enormous risk. The historical increases in greenhouse gas emissions owing to greater usage of fossil fuel energy and economic expansion have exacerbated global warming calamities such as the floods that occurred in Kwa-Zulu Natal (KZN) in April 2022. The KZN floods led to the World Bank’s International Finance Corporation and Business Partners Ltd launching a R720 million Green Building Finance Programme to encourage green building in South Africa, in their interview with News24\(^{34}\). Business Partners Ltd mentioned that this programme is aimed at installing solar panels, water conservation systems and other technologies that will reduce each building’s water and electricity consumption by at least 20%. All emerging and developed economies throughout the world are focused on renewable energy sources for clean and sustainable economic growth, reducing carbon emissions to improving climate conditions. Wind, solar, biomass, hydropower, and geothermal energy could eradicate fossil fuels from the country’s electrical mix. With novel conversion technologies, these cleaner and cheaper energy supplies may boost economic growth based on sustainable renewable energy output\(^{16}\).

**3. METHODOLOGY**

This study adopted a positivist paradigm which focuses on a quantitative research method. The use of questionnaires also allowed the researchers to obtain measurable and bias-free data. A quantitative research approach supports the use of Likert-type scales to assess data\(^{35}\).
In this study, the Likert-type survey determined the benefits of using AP in building façades to reduce CO\textsubscript{2} emissions. To analyse the data, a mean scores of data was used to calculate the central tendency and to determine the average score of the Likert-type scale constructs.

Population and sample focused on implementation of AP systems highlighting CO\textsubscript{2} emission reduction as not only a national subject, but a global one as well. The study was conducted in Johannesburg, South Africa. Johannesburg was selected for the study as it is the capital city and the central business district of Gauteng province. The study was limited to the green building sector. The population of the study comprised participants listed by the Green Building Council South Africa (GBCSA) as professionals using sustainable systems that focus on renewable energy production during their construction processes. A convenience sampling method was also used due to geographical proximity and the participants’ willingness to participate in the study.

**Data Collection**

The questionnaire for the study was distributed electronically (from July 2022 to October 2022) to selected companies. The questionnaire consisted of three sections with a total of 21 questions. The first section, focusing on the respondent’s demographic profile, obtained personal information on profession, area of specialization and the use of any solar gathering or harvesting systems. The second section set 11 Likert-scale statements for the construct “benefits” and the “efficiency” in the implementation of AP systems in building façades. Respondents were requested to rate the level of importance of each benefit on how AP systems are beneficial and other ways CO\textsubscript{2} emissions can be reduced. The third section had 10 Likert-scale items on the construct “challenges” and “applicability” of implementing AP systems in the South African industry. To reduce the respondents’ bias, closed-ended questions were preferred for these sections.

**Data Analysis**

The data for the study was analyzed, using the descriptive statistics. Descriptive statistics are simply the numerical procedures or graphical techniques used to organize and describe the characteristics or factors of a given sample\textsuperscript{37}. The result of the study was presented with percentages, graphs, and ranks. The benefits and challenges of assessing the possibility of applying AP in building facades for on-site energy production for building, which will allow buildings to be self-sufficient in terms of their energy needs were analyzed, using descriptive statistics such as graphs and percentages.

4. **RESULTS AND DISCUSSION**

The Sustainability Goals 7 and 9 for affordable, clean energy in and improving technology in all industry are aiming to increase renewable energy use, improve energy use efficiency, enhance international cooperation regarding clean energy access, and to upgrade technology in developing countries for sustainable energy services. This approach seeks to integrate technologies that will develop clean power and enable energy digitalization to drive energy revolution for a better, greener future. Although the fundamental concept of AP dates to the early 1950s, it is still not generally popular concept within the construction industry. However, in recent years AP has been at the center of attention within different industries. In order to get the most possibly accurate results for this study it was imperative to gauge the participants’ awareness of AP and give a detailed explanation of the concept to get expert based opinion on its efficiency and applicability in the construction industry. In Figure 2, A represents the participants’ knowledge of artificial photosynthesis and B represents the participants’ opinion on the applicability of artificial photosynthesis.
As indicated, after being asked if they had any knowledge of artificial photosynthesis (A), 6 in 10 participants were aware of the technology. And after being given a detailed definition by Dincer and Acar\textsuperscript{38} of artificial photosynthesis (B) which was as follows: \textit{Artificial photosynthesis is a process that mimics natural photosynthesis, where artificial photosynthesis system includes an enzyme bed reactor to remove CO\textsubscript{2} from the atmosphere and create clean green energy and oxygen.}

The participants were then asked if they believe that AP can make any difference in addressing the production and provision of renewable energy which other technologies may have failed to address. The response of 8 out of 10 participants believed that AP could make a difference as most buildings now convert building envelopes to power generation sources that allow for local energy harvesting and usage. In addition to energy generation, glass facades can deliver energy conservation through heat rejection while providing visual comfort.

To instantiate the relevance of this sunlight intensive technology in the construction industry, an investigation on the best source of renewable energy in the context of South Africa and the respondents ranked solar energy as the best source of renewable energy as illustrated in Table 1. This corroborates the finding from a study conducted by Al-Ghamdi and Bilec\textsuperscript{31} which found that solar energy is the most plenteous of all energy sources and can be applied in many ways.

**Table 1: Best Source of Renewable Energy**

<table>
<thead>
<tr>
<th>Factor</th>
<th>N=11</th>
<th>rank</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Thermal</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hydro</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Challenges to APT implementation**

There is a plodding uptake of green building methods in South Africa\textsuperscript{39}, and this is due to various factors ranging from cost of initial implementation, government regulations, availability of materials and suppliers and more. Considering that AP is a futuristic technology, it was vital to investigate the potential challenges to the implementation of this specific technology.

Mimicking the first and second steps of natural photosynthesis (light-harvesting and light-to-electricity
conversion) is relatively straightforward. These are basically what solar panels do. However, photosynthesis is distinguished by its ability to use that electricity to make fuel and materials. To achieve this, researchers need to develop cheap and effective catalysts that speed up the chemical reactions. And the batteries are simply not cut out for powering heavy manufacturing. Because sunlight fluctuates in daily and seasonal cycles, the absence of effective storage solutions is a major obstacle to scaling renewables. The results illustrated in the figure below show the type of other challenges the respondents face in the construction industry.

Figure 3: Potential Barriers to AP

The respondents ranked the availability of proper materials to build AP (38.9%) as the most likely factor to impede the successful implementation of this technology, followed by the economic conditions of South Africa (22.2%). According to the study by Dosumu & Aigbavboa33, a weak economy was ranked the 2nd highest factor that hinders the adoption of sustainable construction systems in the South African construction industry while illustrating that monetary and budget boundaries are ranked the 4th challenge in the implementation of sustainable construction and as such, lack of finances to acquire sustainable systems ranked number 9. Seemingly, AP technologies are expected to suffer the same fate if implemented in the construction industry.

The increasing energy demand and the aim of achieving zero-energy building necessitates the rapid growth of sustainable solar energy harvesting in most buildings. However, solar energy conversion into electricity requires storage. It will be necessary to choose the storage option compatible with the amount of energy that has to be stored, the length of the storage period, the rates at which energy can be fed into the building. Any kind of storage option needs appropriate materials. In designing for sustainability, material abundance, eco-efficient
processes, toxicity, and scalability should be considered.

Another challenge was the underutilization of smart building facades in the construction industry. It was found that 70% of respondents believe building facades are underutilized because heat flow through the interconnected parts of the structure and create paths of low thermal resistance. These are areas where point thermal bridges exist but with proper design these points can be eliminated, and the facades can be beneficial. There was variance of 0.722 in answering this question from the respondents as respondents showed the need for smart buildings facades in sustainability, not just use them for aesthetic purposes.

Figure 4: Underutilization of Smart Building Facades

The production of electricity by the sun on a large scale can be temporally uncorrelated with peak demands especially in urban areas. If the average solar power striking the earth’s surface annually is about 170 Wm² and only a fraction of this power can be converted into fuel or electricity. In practice, solar renewable energies have average annual power densities ranging between 5–20 Wm² using PV panels. Power densities of final energy uses in modern societies range between 10 and 70 Wm² for houses and low energy intensity manufacturing buildings, sustainable facades will support. And the grid can accommodate up to 30% of electricity from intermittent renewable sources without the need for dedicated storage facilities.

5. CONCLUSION

The process of artificial photosynthesis only relies on solar energy to produce oxygen and energy-rich compounds that can be used as an alternative source of renewable energy. This process can be accomplished by a handful of device designs, like building facades using AP to extract energy from the sun rays. AP in building facades also create a more useable source of energy than solar panels, which are currently the most popular and commercially viable form of solar power.

The results of this study AP will be an advancement to the existing technology of solar PV systems and that the general application of AP in the built environment will potentially have a positive impact in the reduction of CO₂ emissions and the enhancement of on-site energy production. However, the construction industry and its property developers are still hesitant about this technology, the core reason for this hesitation is that implementing AP could potentially compromise the aesthetical presentation of buildings. The solution to this hesitation will be the new designs of building facades using AP technologies and the choice of materials.

Photosynthesis avoids the storage problem that wracks renewables. This is because it goes a step further than simple electricity generation. Just like plants, it converts the solar electricity into stable, high-energy substances, fuels and high-value materials. In short, while solar panels create electric charge, but AP in building facades creates more from that charge.
6. REFERENCES


187: 390-402.


ASOCSA2023 - [015]

Measures for stakeholders’ participation and grievance management in Transmission Company of Nigeria (TCN) projects.

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ABSTRACT

Purpose
The participation of stakeholders and grievance management are critical components of stakeholders’ engagement. This study aims to assess measures for stakeholders’ engagement and grievance management on TCN projects in Nigeria. The objectives are to determine the frequency of use of measures for stakeholders’ participation and grievance management measures in TCN Power projects.

Design methodology
The study used a survey research approach. The population was divided into two groups: construction professionals and electricity consumers. The study employed a multi-sampling strategy that included both purposeful and simple random sampling techniques. Structured self-administered questionnaires were used to extract information from the respondents in Lagos. Each of the first and second groups of participants received 50 copies of the questionnaire, while 29 and 41 questionnaires were returned, indicating 58% and 82% response rates for the two groups respectively. Data were analyzed using frequency, percentages, mean scores and ranking.

Findings
Results indicate that supervision and control is the most frequently used measure for stakeholders’ participation; while decisions at the design stage to ensure proper planning and review of project plans and specifications is the commonest used grievance management measure.

Research implications

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
The study concludes that grievance management measures are commonly engaged in TCN projects, however, appropriate decisions at the design stage and consultations with the stakeholders before project commencement are among the commonest. The implication is that conflicts could tend to be lesser in TCN projects. The study recommends that TCN organizations and professionals should be cognizant of the various measures established in this research for full implementation on projects. This can be achieved through appropriate dissemination.

**Keywords:** Grievance Management, Measures, Stakeholders’ Participation, TCN Projects.
1. INTRODUCTION

The power sector is an essential component of every country's growth. The sector is divided into three major subsectors in Nigeria comprising generation, transmission and distribution. Among these three subsectors, power transmission is vital to the energy sector (Pall et al., 2016). Electric Power Transmission is simply the act of transporting huge amounts of energy from producing stations over vast distances for ultimate consumption by customers. The Transmission Company of Nigeria (TCN) distributes energy in Nigeria. Abdulaziz (2022) notes that TCN is one of the 18 firms that emerged from the former Power Holding Company of Nigeria (PHCN). Since transmission projects involve many types of stakeholders, the needs, viewpoints and levels of engagement among its stakeholders vary from project to project. Edomah et al. (2021) add that these stakeholders play crucial roles in the construction and operation of electrical infrastructure. Stakeholders' participation is viewed as a means of smoothing planning procedures, reducing resistance, resolving disputes and developing the grid by addressing stakeholders' diverse concerns and demands (Rottmann, 2013). While formal stakeholder input is currently incorporated in transmission line design procedures, numerous researchers and groups argue that it could be done differently and better (Ciupuliga & Cuppen, 2013). Yet, it is thought that increasing stakeholder engagement is a prerequisite for higher project satisfaction (Komendantova et al., 2015). Bal et al. (2013) suggest six steps to the stakeholder engagement process which include identification, relating stakeholders to different sustainability-related targets, prioritizing the stakeholders, managing stakeholders, measuring performance and putting targets into action. Riahi (2017) noted stakeholders' identification as the process which involves identifying the persons, groups or organizations that may affect a decision, or be affected by project activity, or its final outcome. Riahi (2017) explained further that the process also analyzes and documents relevant information about stakeholder interests, participation, interdependencies, influence and potential impact on the success of the project. Moreover, Nakayenze et al. (2021) posit that the procedures in the grievance management process include complaint identification or receipt, complaint investigation and complaint handling or resolution. Danku et al. (2015) posit that the management of firms often includes grievance procedure for managing various concerns in order to protect the relationships between employees and to preserve harmony in the workplace. The management of complaints is an important aspect of organizations. This is because grievance processes give employees a way to voice concerns about management choices or practices and have those issues looked into and addressed (Hardman, 2004). This research aims to assess measures for stakeholders' engagement and grievance management on TCN projects in Nigeria. The objectives are to determine the frequency of use of measures for stakeholders' participation; and frequency of use of grievance management process in TCN Power projects. The study is significant because it demonstrates the extent of stakeholders' existing participation and grievance management in TCN's operations, which significantly helps both the public sector's opinion of TCN's stance and the engagement of its stakeholders.

2. LITERATURE REVIEW

2.1 Grievance Management Measures in TCN Projects

The treatment of employee complaints or dissatisfaction through a formal grievance handling procedure is known as grievance management (Nakayenze et al., 2021). It is a plan developed by companies to address any real or imagined source of unhappiness or unfairness a worker feels about their position, including organizational management rules and procedures as well as elements of the external environment (Rees et al., 2017). Employees are crucial to any firm, thus, managers seek to reduce disputes and other issues that develop at work by resolving them according to established process. Unresolved or badly managed grievances have significant impact on an organization's production, morale, industrial peace and motivation. As a result, it is often treated seriously. According to the Nigerian Rural Electrification Project, the potential issues and grievances to manage on TCN projects include cables and poles passing through or above homes and
other privately-owned properties; environmental issues brought on by the presence of batteries and other equipment or waste management (e.g. battery disposal); land acquisition; access restriction and relocation; the exclusion of community members from the workforce or paid labour; the exclusion of women from TCN projects; non-inclusion of community people in choices about the Mini Grid’s design, operation, and billing process; existing political differences in communities, and the resulting perception of the initiative as favoring one split. Community people have unreasonable Corporate Social Responsibility (CSR) expectations of contractors. Other issues of grievances comprise high service costs, for example, community members are usually required to pay a one-time ‘connection fee’ covering the cost of a breaker and cables to connect power from poles to users’ houses or business premises; conflicts arising from bypassing meters to use free electricity; complaints about high tariffs; commercial electricity users paying a higher tariff than others; prolonged outages in electricity supply due to faulty equipment; delays in project execution leading to collapse in trust (e.g., delays in take-off after the contractor has mobilized equipment to site); disruption of public access and disturbance, resulting in lost business days and associated income; disagreements over product warranty; accidents or injuries due to construction; loss of vegetation; and potential risk of gender-based violence/sexual harassment (GBV) of locals as a result of construction. According to TCN (2020), grievance redress procedures for TCN projects include receiving a complaint; acknowledging the complaint; screening and determining the merit of the grievance; implementing and monitoring a redress action; extra intervention for a dissatisfied complaint; judicial adjudication; and funding of the grievance process. Additionally, the Nigerian Distribution Sector Recovery Program [DISREP] (2020) established a six-step comprehensive grievance resolution procedure that encompasses uptake, sorting and processing, acknowledgement and follow-up, verification, investigation and action, monitoring and evaluation, and feedback.

2.2 Measures for stakeholders’ participation in TCN Power projects

Previous studies have described stakeholder participation using a range of terminology, such as “co-creation,” “engagement,” “interaction,” “co-design,” and “involvement,” all of which allude to the inclusion of stakeholders in innovative and decision-making processes (Steen et al., 2011; Ordanini & Parasuraman, 2011). These innovation and decision-making processes are carried out in collaboration with stakeholders, but if several stakeholders are involved, that may be problematic (Lannon & Walsh, 2020). Some researchers use the concept of “co-” to stress that participation is accomplished in partnership with stakeholders, such as when value is “co-created” (Smyth et al., 2018) or “co-designed” (Steen et al., 2011; Blomkamp, 2018; Deserti et al., 2020). For instance, Steen et al. (2011) investigated the co-design processes used in three development projects, and the co-design process involved project stakeholders. Reed (2008) notes that stakeholders’ participation strategies should be adopted once the process’s objectives have been clearly stated, the required degree of engagement has been specified and relevant stakeholders have been identified (Reed, 2008). However, Luyet et al. (2012) provided a framework of five stages of stakeholder participation. These comprises information, consultation, collaboration, co-decision and empowerment.

3. RESEARCH METHOD

Cross-sectional survey research design was used for the study. This research work focused on three TCN projects construction sites (Ayobo 132kv, Ilase 132KV and Alagbon 330KV Transmission Stations) within Lagos, Nigeria. The study population comprised construction professionals and energy consumers of the three case projects. Zikmund (2003) asserts that sampling technique are those methods used in choosing the elements that represent a subject from a defined population, such way that bias is avoided. Purposive sampling technique was used, which enabled the study to target and administer questionnaires to employees of TCN such as Engineers, Supervisors, Managers and other key personnel at Ayobo, Ilase and Alagbon Transmission Stations in Lagos State, Nigeria, as well as the residents in the community. Structured questionnaire was
administered to elicit information from the targeted respondents. The questionnaire was divided into three sections. Section A comprised the demographic information while the other sections contain items on the variables of interest. Section B enlisted 18 grievance management measures, measured on a 5-point Likert scale namely: never, rarely, seldom, most times and always. Section C examined 13 frequency of use of measures for stakeholders’ participation in TCN Power projects. The frequency of use of the measures were measured on a 5-point Likert scale namely: never, rarely, seldom, most times and always. A total of 50 copies of questionnaires each were distributed to the first and second categories of respondents. At the end of the survey period, a total of 29 and 41 questionnaires were duly completed and retrieved representing 58% and 82% response rates for the two groups respectively. These are good response rates considering the difficulties in getting responses to questionnaires in Lagos state. Data obtained from the administration of the questionnaires were analyzed with the aid of Statistical Package for the Social Sciences (SPSS) version 23.0. Frequency tables, percentages, mean score and ranking were used as statistical tools of analyses.

4. FINDINGS AND DISCUSSION

4.1 Demographic Profile

The respondents’ and organizations’ profiles of the TCN projects investigated are presented in Table 1. Results from Table 1 shows that 82.8% of the professionals were male and 17.2% were female; and 75.6% of the consumers were male and 24.4% were female. Similarly, 24.1% of the professionals were within the age group of 18-30years, 34.5% between 31-40years, 37.9% between 41-50years, and 3.4% between 51 years and above; while 14.6% consumers were between 18-30years old, 36.6% between 31-40years, 34.1% between 41-50years, and 14.6% between 51 years and above. Also, 34.5% of the professionals have higher national diploma (HND) degree, 37.9% have Bachelors degree, 10.3% have post graduate diploma (PGD) degree, 13.8% have Masters degree and 3.4% have other educational qualifications; 39.0% of the consumers have HND degree, 36.6% have Bachelors degree, 4.9% each have PGD and Masters degrees, and 14.6% have other educational qualifications. Additionally, 3.4% of the professionals were Builders, 6.9% were Civil Engineers, 82.8% were Electrical Engineers, 6.9% were other professionals such as Quantity Surveyors, Architects and so on. Moreover, 27.6% of the professionals have been working with TCN for between 1-5 years, 31.0% between 6-10 years, 10.3% between 10-15 years, 6.9% between 15-20years, 20.7% between 20-25 years and 3.4% for above 25 years. As much as 10.3% of the professionals were project managers, 48.3% were engineers, 6.9% were assistant engineers, 3.4% were site supervisors, 13.8% were technicians and 17.2% were in other working positions with TCN. Furthermore, 51.7% of the professionals had been involved in less than 5 power transmission projects (PTPs), 20.7% in 6-10 PTPs, and 27.6% in above 10 PTPs. In addition, Result from Table 1 showed that among the consumers, 68.3% were urban settlers and 31.7% were rural settlers; 2.4% were unemployed, 7.3% were traders, 39.0% were professionals, 43.9% were civil servants, and 7.3% were artisans; 34.1% were from Ayobo/Iyana Ipaja community, 36.6% from Ilase, and 29.3% from Alagbon; 53.7% were involved in TCN projects while 46.3% were not; lastly, 72.7% have been stakeholders for 1-5 years, 4.5% for 6-10 years, 9.1% for 10-15 years, 4.5% each for 15-20 years, 20-25 years, and above 25 years. It can be inferred that the respondents could provide the relevant information for the objectives of the study.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Professionals</th>
<th>Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24</td>
<td>82.8</td>
</tr>
<tr>
<td>Female</td>
<td>5</td>
<td>17.2</td>
</tr>
</tbody>
</table>

Table I: Demographic profile of the Nigerian respondents
### Age

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Total</th>
<th>18-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51 and above</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-30</td>
<td>29</td>
<td>6</td>
<td>15</td>
<td>14</td>
<td>6</td>
<td>29</td>
</tr>
<tr>
<td>31-40</td>
<td>10</td>
<td>34.5</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>41-50</td>
<td>11</td>
<td>37.9</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>51 and above</td>
<td>1</td>
<td>3.45</td>
<td></td>
<td></td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>100.0</td>
<td>41</td>
<td>100.0</td>
<td>14.63</td>
<td>100.0</td>
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</table>

### Qualifications

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Total</th>
<th>HND</th>
<th>Bachelors</th>
<th>PGD</th>
<th>Masters</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HND</td>
<td>10</td>
<td>34.5</td>
<td></td>
<td>16</td>
<td></td>
<td>4</td>
<td>39</td>
</tr>
<tr>
<td>Bachelors</td>
<td>11</td>
<td>37.9</td>
<td></td>
<td>15</td>
<td></td>
<td>4</td>
<td>36.6</td>
</tr>
<tr>
<td>PGD</td>
<td>3</td>
<td>10.3</td>
<td></td>
<td>2</td>
<td></td>
<td>4</td>
<td>4.9</td>
</tr>
<tr>
<td>Masters</td>
<td>4</td>
<td>13.8</td>
<td></td>
<td>2</td>
<td></td>
<td>4</td>
<td>4.9</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>3.4</td>
<td></td>
<td>4</td>
<td></td>
<td>4</td>
<td>14.6</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
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<td>100.0</td>
<td>41</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

### Profession

<table>
<thead>
<tr>
<th>Profession</th>
<th>Total</th>
<th>Builder</th>
<th>Civil Engineer</th>
<th>Electrical Engineer</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Builder</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>Civil Engineer</td>
<td>2</td>
<td></td>
<td>6.9</td>
<td></td>
<td></td>
<td>6.9</td>
</tr>
<tr>
<td>Electrical Engineer</td>
<td>24</td>
<td>82.8</td>
<td></td>
<td></td>
<td></td>
<td>27.8</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>6.9</td>
<td></td>
<td></td>
<td></td>
<td>14.9</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Work experience in TCN

<table>
<thead>
<tr>
<th>Years</th>
<th>Total</th>
<th>1-5 years</th>
<th>6-10 years</th>
<th>10-15 years</th>
<th>15-20 years</th>
<th>20-25 years</th>
<th>Above 25 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 years</td>
<td>8</td>
<td>27.6</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>27.6</td>
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<tr>
<td>6-10 years</td>
<td>9</td>
<td>31.0</td>
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<td></td>
<td></td>
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<td>31.0</td>
</tr>
<tr>
<td>10-15 years</td>
<td>3</td>
<td>10.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.3</td>
</tr>
<tr>
<td>15-20 years</td>
<td>2</td>
<td>6.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.9</td>
</tr>
<tr>
<td>20-25 years</td>
<td>6</td>
<td>20.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20.7</td>
</tr>
<tr>
<td>Above 25 years</td>
<td>1</td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
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<td></td>
<td></td>
<td></td>
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<td>100.0</td>
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</tbody>
</table>

### Work position in TCN

<table>
<thead>
<tr>
<th>Position</th>
<th>Total</th>
<th>Project manager</th>
<th>Engineer</th>
<th>Assistant engineer</th>
<th>Site supervisor</th>
<th>Technician</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project manager</td>
<td>3</td>
<td>10.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.3</td>
</tr>
<tr>
<td>Engineer</td>
<td>14</td>
<td>48.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48.3</td>
</tr>
<tr>
<td>Assistant engineer</td>
<td>2</td>
<td>6.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.9</td>
</tr>
<tr>
<td>Site supervisor</td>
<td>1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>Technician</td>
<td>4</td>
<td>13.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13.8</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>17.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17.2</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Number of TCN projects executed

<table>
<thead>
<tr>
<th>Number of projects executed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less Than 5</td>
<td>51.7</td>
</tr>
<tr>
<td>6-10</td>
<td>20.7</td>
</tr>
<tr>
<td>Above 10</td>
<td>27.6</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Settlement of Consumers

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Total</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>28</td>
<td>68.3</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>13</td>
<td></td>
<td>31.7</td>
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</table>
Table 2 examined the frequency of use of measures for stakeholders’ participation in TCN power projects. Table 2 shows that the highest ranked measure is supervision and control (4.62), followed by health and safety standards during project operational phase (4.59), and operation and maintenance (4.48). These three measures have been opined crucial for a framework for stakeholders’ engagement in TCN power projects. Supervision is a crucial measure that cannot be overlooked in a project like the TCN. TCN is a high-capital-intensity project that must be closely monitored from start to finish. For effectiveness to be achieved, supervision must include all key stakeholders. TCN projects must be closely monitored both during construction and after completion throughout the operating period. Proper construction supervision promotes quality and on-time delivery. Control also aids in construction waste reduction and enhances project participants’ commitments. As a result, supervision and control are one of the important measures necessary for stakeholders to participate in TCN power projects. Another measure necessary for stakeholders’ engagement in TCN power projects is health and safety requirements during the project operating period. At the operational phase of TCN, health and safety are essential concepts that must not be overlooked. Defined health and safety protects the well-being of site workers and their surroundings. Health and safety in relation to the TCN project operational phase is concerned with caring for the health of the operators and the general public inside the premises in order to protect them.
from harm or accident throughout the operation process. Health and safety are assured by instituting specific procedures and rules that address operator and public safety, thereby eliminating or minimizing the likelihood of accidents occurring or operators being injured throughout the operation process. The importance of health and safety is inherent in the utmost protection of the environment and the operators, the safeguarding of operators' health through accident control, and ensuring a conducive, healthy, and safe operational environment that allows for workers to deliver optimally while at work. Appropriate maintenance has become critical and cannot be overstated in contributing to the TCN project's effective and efficient functionality during the operational phase, supporting successful operations. TCN projects having the potential to fail in functionality due to non-compliance of design criteria, maintenance, and accidents occurring or operators violating waste disposal regulations. Hence, all maintenance plans must be in place for the projects to continue to deliver optimally that fosters functionality of the project.

Table 2: Measures for stakeholders’ participation in TCN Power projects

<table>
<thead>
<tr>
<th>Measures</th>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>TS</th>
<th>Std</th>
<th>MS</th>
<th>RK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervision and control</td>
<td>29</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>25</td>
<td>4.62</td>
<td>1.083</td>
<td>4.62</td>
<td>1</td>
</tr>
<tr>
<td>Health and Safety Standards during project operational phase</td>
<td>29</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>20</td>
<td>4.59</td>
<td>0.733</td>
<td>4.59</td>
<td>2</td>
</tr>
<tr>
<td>Operation and maintenance</td>
<td>29</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>9</td>
<td>18</td>
<td>4.48</td>
<td>0.829</td>
<td>4.48</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Impact Analysis</td>
<td>29</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>17</td>
<td>4.41</td>
<td>0.825</td>
<td>4.41</td>
<td>4</td>
</tr>
<tr>
<td>Proposal and preliminary design evaluation</td>
<td>29</td>
<td>2</td>
<td>-</td>
<td>9</td>
<td>10</td>
<td>17</td>
<td>4.38</td>
<td>1.049</td>
<td>4.38</td>
<td>5</td>
</tr>
<tr>
<td>Delivery and commissioning</td>
<td>29</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>18</td>
<td>4.38</td>
<td>1.015</td>
<td>4.38</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Site assessment and analysis report</td>
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<td>1</td>
<td>2</td>
<td>10</td>
<td>16</td>
<td>4.34</td>
<td>0.974</td>
<td>4.34</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Hazard mitigation measures</td>
<td>29</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>17</td>
<td>4.31</td>
<td>0.967</td>
<td>4.31</td>
<td>8</td>
</tr>
<tr>
<td>Project’s brief/presentation and feasibility studies</td>
<td>29</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>15</td>
<td>4.28</td>
<td>1.066</td>
<td>4.28</td>
<td>9</td>
</tr>
<tr>
<td>Vendors, contractors and other TCN project stakeholders’ compliance to the requirements of extant laws and regulations</td>
<td>29</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>14</td>
<td>11</td>
<td>4.21</td>
<td>0.774</td>
<td>4.21</td>
<td>10</td>
</tr>
<tr>
<td>Project selection support at the early phases</td>
<td>29</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>17</td>
<td>8</td>
<td>4.14</td>
<td>0.639</td>
<td>4.14</td>
<td>11</td>
</tr>
<tr>
<td>Project performance data metrics</td>
<td>29</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>13</td>
<td>10</td>
<td>4.07</td>
<td>0.884</td>
<td>4.07</td>
<td>12</td>
</tr>
<tr>
<td>Trades and labour personnel supportive of TCN project safety practices as evidenced by the frequency of complaints or grievances</td>
<td>29</td>
<td>-</td>
<td>3</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>3.69</td>
<td>0.93</td>
<td>3.69</td>
<td>13</td>
</tr>
</tbody>
</table>

1= Never, 2= rarely, 3= Sometimes, 4= Most times, 5= Always, TS= Total Score, Std= Standard Deviation, MS= Mean Score, RK= Rank, N=Number of respondents

4.3 Grievances Management Measures on the Selected Projects

Table 3 examines the frequency of use of grievances management measures on the selected projects. It can be seen in Table 3 that decisions at design stage to ensure proper planning and review of project plans and specifications were ranked 1st by the professionals but ranked 2nd by the consumers. Consultations with stakeholders before commencing TCN project ranked 2nd by the professionals and 4th by the consumers. Engagement of qualified personnel with specialized knowledge to handle key positions all through the phases of construction of TCN project ranked 3rd (4.38) by the professionals but 1st (4.02) by the consumers. It was deduced on site that all these measures were implemented which minimized the occurrence of grievances on the projects. The design phase of projects is crucial and largely determines the project operating efficiency mostly in terms of maintenance, repairs and rework after completion. Hence the need for a well-planned design that fosters functionality of the project. On the TCN projects therefore, the design phase incorporated proper planning, while this is also reviewed to ensure compliance with specifications. Stakeholders were...
consulted and integrated on the three projects investigated. This prepares them ahead of the implementation and creates an avenue for smooth implementation in the host communities, thereby ensuring successful delivery. Additionally, qualified personnel with specialized knowledge were seen handling key positions from commencement to the completion phase of the TCN projects. Grievance management was taken as an important concept that influence on the successful implementation and delivery of TCN project. This way, grievances were mitigated all through the different phases of the construction process and project gets efficiently managed.

Moreover, least ranked measures include modification of conducts that caused grievances ranked 15th (3.90) by the professionals and 14th (3.51) by the consumers; adequate grievance documentations devoid of errors and omissions ranked 17th (3.79 by professionals and 3.41 by consumers); establishment of appropriate mechanisms for early identification of potential grievance issues and allocating fair contract risk of TCN project ranked 18th. Overall, it can be observed that all the measures are implemented on TCN projects because the least two measures frequently implemented have 3.41 and 3.32 means (‘sometimes implemented’) on the Likert scale; while all other measures’ means are above 3.5 (‘most times implemented’).

Table 3: Grievances Management Measures on the Selected Projects

<table>
<thead>
<tr>
<th>Measures</th>
<th>Professionals Mean</th>
<th>Professionals Rank</th>
<th>Consumers Mean</th>
<th>Consumers Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decisions at design stage to ensure proper planning and review of project plans &amp; specifications</td>
<td>4.48</td>
<td>1</td>
<td>3.88</td>
<td>2</td>
</tr>
<tr>
<td>Consultations made with stakeholders before commencing TCN project</td>
<td>4.41</td>
<td>2</td>
<td>3.8</td>
<td>4</td>
</tr>
<tr>
<td>Employment of qualified personnel with specialized knowledge to handle key positions all through the phases of construction of TCN project</td>
<td>4.38</td>
<td>3</td>
<td>4.02</td>
<td>1</td>
</tr>
<tr>
<td>Evaluation of complaints and corrective action taken</td>
<td>4.21</td>
<td>4</td>
<td>3.68</td>
<td>9</td>
</tr>
<tr>
<td>Interactions and negotiation with identified affected persons before commencing TCN projects</td>
<td>4.21</td>
<td>4</td>
<td>3.76</td>
<td>6</td>
</tr>
<tr>
<td>Clear instructions on how the issues would be tackled and the next steps that all parties would be responsible to take in order to bring the issue to rest.</td>
<td>4.17</td>
<td>6</td>
<td>3.56</td>
<td>12</td>
</tr>
<tr>
<td>Prompt resolve of issues in an effective and efficient way before commencement</td>
<td>4.10</td>
<td>7</td>
<td>3.66</td>
<td>10</td>
</tr>
<tr>
<td>A comprehensive, clear and timely response to questions/issues brought forward</td>
<td>4.10</td>
<td>7</td>
<td>3.59</td>
<td>11</td>
</tr>
<tr>
<td>Allocating fair contract risk of TCN project</td>
<td>4.10</td>
<td>7</td>
<td>3.32</td>
<td>18</td>
</tr>
<tr>
<td>Improvement in communication channels through the use of phone calls, SMS, and email all through the phases of TCN project construction</td>
<td>4.07</td>
<td>10</td>
<td>3.78</td>
<td>5</td>
</tr>
<tr>
<td>Education of stakeholders on their rights and obligations prior to commencement of TCN project construction</td>
<td>4.00</td>
<td>11</td>
<td>3.73</td>
<td>7</td>
</tr>
<tr>
<td>Consideration of grievance management as fundamental parts of a project’s process</td>
<td>4.00</td>
<td>11</td>
<td>3.88</td>
<td>2</td>
</tr>
<tr>
<td>Practice of participative management all through the construction period of TCN project</td>
<td>3.97</td>
<td>13</td>
<td>3.51</td>
<td>14</td>
</tr>
<tr>
<td>Presentation of grievances following a stated due process</td>
<td>3.93</td>
<td>14</td>
<td>3.56</td>
<td>12</td>
</tr>
<tr>
<td>Resolve of grievances using the Grievance Redress Committee</td>
<td>3.90</td>
<td>15</td>
<td>3.51</td>
<td>14</td>
</tr>
<tr>
<td>Modification of conducts that caused the grievance</td>
<td>3.90</td>
<td>15</td>
<td>3.51</td>
<td>14</td>
</tr>
<tr>
<td>Adequate grievance documentation devoid of errors and omissions.</td>
<td>3.79</td>
<td>17</td>
<td>3.41</td>
<td>17</td>
</tr>
<tr>
<td>Establishment of appropriate mechanisms for early identification of potential grievance issues</td>
<td>3.72</td>
<td>18</td>
<td>3.73</td>
<td>7</td>
</tr>
</tbody>
</table>
5. CONCLUSIONS

This research appraises measures for stakeholders' participation and grievance management on TCN projects in Nigeria. Survey research strategy was used to carry out the study. The study concludes that supervision and control is the most frequently used measure, though, all other measures were also used at varying frequencies in TCN projects. It therefore implies that success in TCN projects can be linked with the integration of stakeholders via these measures. It can be inferred that this finding align with Steen et al. (2011) and Ordanini and Parasuraman (2011), which both established the involvement of stakeholders in TCN projects and could be traceable to the employment of measures like supervision and control among others. Moreover, grievance management measures are commonly engaged in TCN projects, however, appropriate decisions at the design stage and consultations with the stakeholders before project commencement are among the commonest. The implication is that conflicts could tend to be lesser in TCN projects. This finding does not agree completely with DISREP (2020) because none of the six-step comprehensive resolution procedure in DISREP (2020) is appropriate decision at the design stage. Similarly, TCN (2020) did not also include the topmost measure discovered in this study. Nonetheless, all the studies agree that grievances should be resolved via specific measures and procedures.

6. RECOMMENDATION

The following recommendations are based on the conclusions drawn from the study's findings.

1) TCN organizations and professionals should be cognizant of the various measures established in this research for full implementation on projects. This can be achieved through appropriate dissemination of the measures among the organizations and professionals.

2) Due consideration should also be given to the appropriate grievance management measures on TCN projects. This may be done by creating a functioning feedback mechanism via effective communication structure that includes all relevant stakeholders.

7. LIMITATIONS OF THE STUDY AND FUTURE RESEARCH

This study is perception-based on measures, however, quantitative determination of the actual engagement of stakeholders and grievance management measures on TCN projects are needed. Additionally, only three TCN projects were used which may not be true representation of such projects in the whole of Nigeria, thus, generalization of the findings should be done with caution. Future researches are suggested to venture into the aforementioned aspects.

8. REFERENCES

Olutunji Joseph Oladiran, Iruka Chijindu Anugwo, Raphael Abiodun Ojelabi and Oladunni Remi Bamidele


ABSTRACT

Purpose of this paper
This literature review investigates the potential synergy of artificial intelligence (AI), asset information management (AIM), and healthcare facilities management. It aims to understand the challenges in the field, the effectiveness of traditional methods, and how AI and AIM can improve healthcare facilities management.

Design/methodology/approach
The methodology involves a comprehensive literature search across multiple databases, adhering to specific selection criteria to ensure relevance and significance. The selected studies were meticulously analysed and synthesised to provide an overarching understanding of the field's current state.

Findings
The review reveals that traditional maintenance methods often fall short in managing the rapidly evolving needs of healthcare facilities. However, integrating AI in the context of AIM shows potential for overcoming these challenges with real-time updates, bidirectional coordination, and advanced data analytics capabilities. AI's potential impact on broader sectors, such as the Architecture, Engineering, Construction, and Operation (AECO) industry, is also discussed, highlighting the role of effective data management in information-intensive activities.

Research limitations/implications
The review identifies several gaps in the existing literature, suggesting a need for more empirical studies evaluating the operational outcomes influenced by the integration of AI and AIM and strategies for improved resource allocation and utilisation through AI-driven decision-making. It calls for research into streamlined workflow processes, optimised facility operations, and enhanced maintenance and repair activities using AI-powered predictive analytics.
Practical implications
The practical implications of the findings suggest that AI integration can enhance operational efficiency, reduce costs, and contribute to improved patient care in healthcare facilities management. This underscores the urgent need for more evidence-based insights on the impact of AI and AIM on facilities management efficiency and effectiveness. This review provides valuable insights into the synergy of AI, AIM, and healthcare facilities management, which could be instrumental for researchers and practitioners. It sets the stage for future studies in this domain and has implications for theoretical research and practical applications.

What is the original/value of paper
This review provides valuable insights into the synergy of AI, AIM, and healthcare facilities management, which could be instrumental for researchers and practitioners. It sets the stage for future studies in this domain and has implications for theoretical research and practical applications.

Keywords: Artificial Intelligence, Asset Information, Healthcare, Facilities, Integration, Synergy
1.0 BACKGROUND

In the past few decades, the significance of building maintenance has grown significantly owing to the continuous advancements in facilities and the necessity to uphold optimal operational conditions. The maintenance tasks carried out in healthcare facilities hold immense importance as they are closely tied to the individuals’ safety (Gómez-Chaparro et al., 2020). According to Yousefli et al. (2020), healthcare facilities have become more complex due to urbanisation and technological advancements, resulting in increased demand and a wider range of services provided to many patients. However, these facilities deteriorate faster and face the additional challenge of continuous occupancy and usage throughout the year. This is also noted by Fotovatfard and Heravi (2021) that currently, advanced healthcare facilities exhibit a greater rate of degradation in comparison to other types of buildings. This is primarily attributed to the uninterrupted use of medical equipment, which causes changes in the functions of the building over time. Additionally, the equipment’s wearing down, and the sensor calibration’s displacement further contributes to this elevated deterioration.

Healthcare Facilities Management and Asset Management (AM) have gained significant attention in the Architecture, Engineering, Construction, and Operation (AECO) industry due to their undeniable contribution to the economy. Effective data management plays a critical role in FM because it involves various information-intensive activities, including collecting, analysing, recording, exchanging, and managing extensive facility-related information by facility managers (Demirdöğen et al., 2023). Conducting technical inspections is crucial to minimise excessive expenditures. However, these inspections often fail to assess asset conditions comprehensively and may overlook minor faults. As a result, these undetected issues can lead to more significant problems in ongoing processes (Demirdöğen et al., 2022). Introducing AI technology is crucial to optimising data management and improving technical inspections in healthcare facilities. AI can automate information-intensive activities, detect faults, and identify potential issues. Leveraging AI in asset management enhances operations, reduces costs, and improves patient care.

The increasing importance of information and technology management is evident with the emergence of intelligent buildings that utilise smart objects, IoT sensors, digital twins (DT), and building information modelling (BIM). Implementing artificial intelligence (AI) in hospital building facilities enables better management strategies and optimisation of processes through structured organisation and treatment of information. These technologies enhance the management of the built environment and optimise operations within healthcare facilities (Pedral Sampaio et al., 2023). Madubuike and Anumba (2023) noted AI possesses crucial features that can address the limitations in healthcare facilities’ Asset Information Management (HFAIM). These features include real-time updates and bidirectional coordination, which enable continuous monitoring and control of the performance of physical assets within healthcare facilities. By leveraging AI, HFAIM can be enhanced, improving efficiency and effectiveness in managing asset information in healthcare settings. In addition, AI enables increased visibility and efficiency in data utilisation by providing a virtual collaborative platform that hosts multidimensional capabilities. This platform allows users to share data and insights in real time, which can help to improve decision-making and optimise operations (Keskin et al., 2022). Implementing AI in HFAIM leads to dynamic and interconnected relationships between the new technology and the pre-existing social systems, technologies, and physical environments (Fanta & Pretorius, 2023).

This paper seeks to explore the potential synergies between Artificial Intelligence (AI), Asset Information Management (AIM), and Healthcare Facilities Management (HFM) in the context of lean concepts. While some existing references exist to the use of AI in healthcare facilities and the AIM industry, it remains unclear how much of the research focuses specifically on integrating these three concepts. Therefore, this study aims to investigate the areas where AI, AIM and healthcare facilities demonstrate potential synergies by examining current challenges and proposing how this concept can effectively address these challenges.

This literature review investigates AI, AIM, and HFM’s collaborative potential to enhance healthcare
facility management practices. By examining existing research and scholarly articles, this study sheds light on the integration possibilities and advantages these technologies and concepts can offer the healthcare industry. The findings of this review will provide valuable insights for practitioners and researchers, facilitating a deeper understanding of how AI, AIM, and HFM can be leveraged effectively.

The background and justification of this study are discussed in the following section, followed by an explanation of the methodology used for the literature review in Section 2. Section 3 provides an overview of AI, while Section 4 explores AIM in healthcare facilities. Section 5 examines the synergy between AI, AIM, and Healthcare Facilities. The impact of this collaborative approach is discussed in Section 6, and Section 7 identifies future research directions and highlights existing research gaps. Finally, Section 8 concludes the review, summarising the key findings and their implications.

2.0 RESEARCH METHOD
A systematic literature review (SLR) assesses and analyses available and pertinent research related to specific keywords or research questions of interest (Silva et al., 2023). According to Sengers et al. (, 2019) SLR is highly valuable for disseminating the main findings of extensive and intricate research literature. It utilises a transparent and rigorous approach, often guided by a predefined protocol, to identify and synthesise all relevant research findings of satisfactory quality about a specific research question or subject. For this study, a research protocol was developed to guide the systematic literature review process. The protocol outlines the research objectives, inclusion and exclusion criteria, search strategy, data extraction methods, and analysis techniques to ensure a comprehensive and unbiased review adapted from (Rad et al., 2022).

To adopt a Systematic Literature Review (SLR), the paper focused on the following aspects: current applications and benefits of integrating AI, AIM, and HFM in healthcare facility management and the research gaps and future directions in integrating AI, AIM, and HFM in healthcare facility management, and what are the potential areas for innovation? The systematic approach used the Web of Science database as the primary information source to ensure a rigorous and comprehensive review of the existing literature. The Web of Science was selected due to its wide coverage of scientific literature across various disciplines, including healthcare, technology, and management (Fang et al., 2020; Zhang et al., 2020). The search strategy involved formulating a research question, identifying key concepts, and constructing a search query using appropriate keywords and Boolean operators. The key concepts in the research question were identified as "Artificial Intelligence," "Asset Information Management," and "Healthcare Facilities Management." A search query was constructed using the identified key concepts. The query included using Boolean operators (AND) to ensure all concepts are present in the search results (Bramer et al., 2018). The search query used in this study used words such as Artificial Intelligence, Asset Information Management, Technology, and Healthcare Facilities Management.

In systematic reviews, which are comprehensive and structured assessments of existing evidence on a specific research question, inclusion and exclusion criteria are used to determine which studies will be included in the review (Booth, 2016). According to Patino and Ferreira (2018), establishing inclusion and exclusion criteria for research subjects is a routine, essential procedure when creating high-quality research procedures. For this study, the following inclusion criteria were established:

- Studies focusing on AIM and healthcare facilities.
- Focusing on the element of AI technologies
- Must be related to the facilities management of healthcare facilities.
- Published between 2012 and 2022
- Written in English
- peer-reviewed conference, journal, and review articles
The exclusion criteria were then.

- Studies are not focusing on the AIM of healthcare-built facilities.
- Not including the element of AI technologies
- Focusing on the facilities and built environment of healthcare facilities.
- Published before 2012 and after 2022
- Not written in English
- Not peer-reviewed conference, journal, and review articles

3.0 OVERVIEW OF ARTIFICIAL INTELLIGENCE (AI)

Artificial intelligence (AI) is a branch of computer science that focuses on building smart computers to carry out activities that ordinarily need human intellect. These include learning, solving problems, perceiving, comprehending natural language, and making decisions. AI techniques have recently permeated various aspects of modern society, including the Internet, finance and insurance sectors, and medical and industrial applications (Bouabdallaoui et al., 2020).

AI plays a crucial role in healthcare activities by facilitating the measurement and evaluation of facility performance. Additionally, it enables benchmarking processes to be carried out effectively by utilising available data (Demirdöğen et al., 2022). AI and decision support systems are essential for managing and exchanging information during the maintenance management process in healthcare facilities. Without these technologies, handling and sharing information would be challenging, hindering effective maintenance practices within the healthcare sector.

Intelligent healthcare facilities have brought about a new era in healthcare facilities management. By incorporating smart objects and IoT sensors throughout the premises, these buildings can create digital twins (DT) and utilise building information modelling (BIM) to develop virtual replicas of the facilities. With artificial intelligence (AI) integration, healthcare facilities are now equipped with advanced tools to optimise processes and implement more effective information-based management strategies. This development is particularly beneficial for hospital building facilities, enabling them to enhance operations, streamline workflows, and improve overall efficiency (Pedral Sampaio et al., 2023).

Within healthcare facilities, AI has been used in managing healthcare assets and supplies, avoiding mistakes, monitoring, and safeguarding data (Abugabah et al., 2021). Through machine learning, AI has also been used to offer the facility management team in hospital buildings an effective strategy for prioritising, planning, scheduling, and executing maintenance interventions (Ahmed et al., 2022). AI in healthcare facilities management also includes applications such as optimising energy consumption, enhancing security, and improving asset management. AI can analyse real-time data on power usage, temperature, and occupancy to optimise energy consumption, resulting in cost reduction and environmental sustainability. Furthermore, AI-powered surveillance systems can monitor and analyse video feeds, contributing to enhanced security measures and ensuring patient and staff safety. Regarding asset management, AI can track and manage medical equipment, supplies, and other assets within healthcare facilities, ensuring efficient allocation and reducing loss or theft.

Additionally, AI in healthcare facilities management offers predictive maintenance capabilities (Ahmed et al., 2022). By analysing data from equipment sensors, AI-powered systems can predict maintenance needs accurately. This proactive approach minimises equipment downtime, optimises performance, and improves operational efficiency. The applications of AI in healthcare facilities management are diverse and impactful. AI significantly benefits healthcare facilities, from information management and maintenance interventions to optimising energy consumption, enhancing security, improving asset management, and enabling predictive maintenance (Abideen et al., 2022). By leveraging AI technologies, healthcare facilities can streamline...
processes, reduce costs, and create more efficient and sustainable environments.

4.0 ASSET INFORMATION MANAGEMENT (AIM) IN HEALTHCARE FACILITIES MANAGEMENT

Asset information management is essential to healthcare facilities management (FM). It covers every stage of a healthcare facility's life cycle, beginning with the design and building phases. However, the dispersed structure frequently found in healthcare building projects creates several difficulties for FM. These challenges manifest as information losses, duplications, error-prone data entry, and disorganised data management throughout the facility's life cycle. Such issues lead to a loss of essential information and necessitate additional efforts to locate accurate project data, which is crucial for effective FM practices in healthcare facilities (Demirdöğen et al., 2021).

According to Lucas et al. (2013), proper facility information management is vital for efficient and safe hospital operations. However, many facility managers face losses in time and money due to poor information transfer and management practices. The information received from earlier lifecycle phases is often incomplete, scattered across multiple systems, and lacks cohesiveness. This makes it challenging to use for completing facility maintenance processes, causing inefficiencies and increased costs. Streamlining information transfer and management is crucial to address these issues and improve healthcare facility management.

Accurate and comprehensive information is vital for healthcare FM as it serves as the basis for informed decision-making, optimal resource allocation, and the seamless operation of healthcare facilities. Unfortunately, the fragmented structure prevalent in healthcare construction projects hampers FM processes, requiring additional resources and time to navigate the scattered information landscape. These challenges pose obstacles to maintaining efficient facility operations and impede the overall effectiveness of FM in healthcare facilities.

By implementing effective AIM strategies, healthcare facilities can streamline their FM processes, improve operational efficiency, enhance patient care, and optimise resource utilisation. AIM enables proactive maintenance and asset management by providing accurate and accessible asset information. This allows facility managers to implement preventive maintenance programs, schedule inspections, and identify potential issues before they escalate into major problems. AIM also supports effective inventory management, ensuring that healthcare facilities have the necessary equipment and supplies at the right time and place.

AIM facilitates compliance with regulatory requirements and standards in the healthcare industry. Maintaining comprehensive asset information helps healthcare facilities demonstrate compliance during inspections and audits. AIM also enables traceability and accountability by tracking asset maintenance history, certifications, and warranties.

AIM plays a vital role in healthcare facilities by ensuring the availability of accurate and comprehensive asset-related information throughout the facility's life cycle. By implementing effective AIM strategies, healthcare facilities can improve operational efficiency, enhance patient care, optimise resource utilisation, and comply with regulatory requirements. AIM serves as a foundation for informed decision-making and enables proactive maintenance and asset management, ultimately contributing to the overall effectiveness of facility management in healthcare settings.

5.0 SYNERGY OF AI, AIM, AND HEALTHCARE FACILITIES MANAGEMENT

The synergy of AI (Artificial Intelligence), AIM (Asset and Infrastructure Management), and healthcare facilities management holds tremendous potential for transforming healthcare organisations. According to Akanmu et al. (2021), advancements in Artificial Intelligence (AI) and Advanced Information Management (AIM) have opened up new possibilities for integrating technology more seamlessly with the lifecycle of healthcare facilities, reduce costs, and create more efficient and sustainable environments.
facilities. This integration brings numerous benefits, such as real-time monitoring of facility operations and improved predictability and control of lifecycle outcomes. By combining the power of AI and AIM with effective facilities management practices, healthcare providers can achieve enhanced operational efficiency, improved patient outcomes, and superior overall care delivery. Over recent years, AIM and AI technologies have gradually integrated into healthcare facility management. Various tools such as platforms, webpages, computer software, and mobile applications have been created to assist facility managers and contractors in gathering, analysing, and presenting data on facility operations (Chen and Tsai, 2021).

AI and AIM technologies optimise the utilisation of healthcare facility resources. Through predictive analytics and machine learning algorithms, AI can analyse data from various sources, such as patient admissions, staffing levels, and equipment usage, to forecast demand patterns accurately. This enables healthcare facilities to efficiently allocate resources, such as beds, staff, and equipment, based on anticipated needs, reducing waste and improving resource utilisation.

AI and AIM also streamline maintenance processes within healthcare facilities. By leveraging AI-powered predictive maintenance algorithms, healthcare organisations can monitor the condition of critical assets and infrastructure in real time. AI algorithms analyse data from sensors, equipment performance metrics, and historical maintenance records to identify patterns and anomalies that indicate potential failures. This allows for proactive maintenance interventions, minimising downtime, and optimising the lifespan of assets, ultimately ensuring uninterrupted patient care.

The integration of healthcare with Artificial Intelligence (AI) has emerged as a prominent development area. The healthcare sector handles a substantial volume of data that requires continuous processing, hence the usage of Blockchain. There is a growing trend towards digitising clinical records to streamline operations. Smart contracts hold the potential to be applied across various Blockchain fields, enabling optimal performance. The use of Blockchain-based applications, particularly within health facilities, to manage the ledger effectively (Monrat et al., 2019; Tahir et al., 2020). The development of generating Building Information Modeling (BIM) models from 3D laser scanning, scan-to-BIM, and photogrammetry has made significant progress. For instance, advancements have been made to improve the accuracy and efficiency of creating BIM models from scanned data (Bortoluzzi et al., 2019). However, this only helps to query data in BIM since BIM only helps to monitor or store data. Thus, the usage of BIM induces us not to consider continuous improvement in the FM (Demirdöğen et al., 2020). A Digital Twin is a direct replica of physical assets that enables monitoring of their operations. It allows for complex analytics and facilitates interactions between systems and platforms (Madubuike and Anumba, 2021). Its purpose is to utilise a collective digital depiction of a constructed asset, enabling the streamlining of design, construction, and operational procedures, thus providing a dependable foundation for decision-making. BIM operates on a semantic and object-oriented basis, incorporating the ability to create 3D models and enabling users to access extensive information associated with objects and their respective attributes (Marmo et al., 2019).

6.0 AI-AIM Healthcare Core Competencies
Professionals must possess specific core competencies to effectively leverage the synergy of AI and AIM in healthcare facilities management. These competencies encompass a range of skills and knowledge that enable individuals to harness the power of AI and AIM technologies to optimise processes and improve decision-making in healthcare settings. This section will outline the key core competencies required for professionals operating in the AI-AIM healthcare domain. Understanding and developing these competencies are vital for successfully implementing and integrating AI and AIM into healthcare facilities management practices.

6.1 Decision Making
This competency involves effectively collecting and analysing data, identifying patterns and trends, and generating actionable insights for informed decision-making. The decision-making ranges from whether to use AI in healthcare organisations (Abugabah et al., 2020), how to maintain the facilities (Ahmed et al., 2022), and how to use AI as a decision-making tool (Yousefli et al., 2020) based on the provided results. From the SLR, the only article that provided a framework for decision-making competency was by Iadanza and Luschi (2020). The framework proposed an integrated custom decision-support computer-aided facility management informative system for healthcare facilities. Analysis can be a valuable tool for improving the efficiency and effectiveness of healthcare organisations. The system can help organisations to save money, improve compliance, and reduce risk. The study included data, database, tools and user interference as components.

The study limitation of integrated custom decision-support computer-aided facility management informative system for healthcare facilities and analysis is that it was a single-site study. This means that the results may not be generalisable to other healthcare facilities. Additionally, the study was conducted relatively short, so it is unclear how the system would perform over the long term.

The research gap in the field of integrated custom decision-support computer-aided facility management informative systems for healthcare facilities and analysis is that there is no one-size-fits-all solution. Each healthcare facility is unique, and its needs will vary depending on its size, location, and service type. As a result, there is a need for a flexible and adaptable system that can be customised to meet the specific needs of each facility.

Another research gap is that there is a lack of data on the effectiveness of these systems. While some studies have shown that these systems can improve efficiency and reduce costs, more research is needed to confirm these findings and identify the specific benefits of these systems. There is a need for more research on the user experience of these systems. These systems must be easy to use and understand so facility managers and other decision-makers can use them effectively.

6.2 AI technology characteristics

This competency involves a comprehensive understanding of AI systems' key attributes and capabilities. It includes knowledge of AI's adaptability, automation, and decision-making capabilities. According to Sampaio et al. (2023), these technologies enable the systematic organisation, usage, and treatment of systematised information, optimising processes, and regulating the physical environment. Some important characteristics include the integration of existing data (Demirdöğen et al., 2020), simplifying workflow systems (Evjen et al., 2020) and addressing interoperability issues between different platforms (Demirdöğen et al., 2023).

Furthermore, Monrat et al. (2019) highlighted the promising nature of blockchain technology and its potential to revolutionise various industries. However, before widespread adoption can occur, several challenges must be addressed. These challenges include security, scalability, privacy implications, and regulatory considerations.

The research is primarily based on a survey, lacking in-depth analysis of specific blockchain applications or challenges. It also focuses on the potential benefits of Blockchain without discussing risks or limitations extensively. Additionally, the reliance on a literature review restricts the study to the existing research available, and there is a lack of exploration of social and economic implications, as well as a Western perspective bias. Therefore, caution should be exercised when interpreting the article's findings, and further research is needed to address these limitations.

To bridge the identified gaps, conducting more research on blockchain security, scalability, privacy implications, and regulatory considerations is imperative. Addressing these gaps can facilitate the widespread adoption of blockchain technology. The author also emphasises the importance of interdisciplinary collaboration among researchers from various fields to advance the understanding and development of
Blockchain.

<table>
<thead>
<tr>
<th>AI technology</th>
<th>Character</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blockchain</td>
<td>centralised, secure, and transparent system that can be used to record transactions and track assets.</td>
<td>(Demirdöğen et al., 2020; Monrat et al., 2019; Peral et al., 2020; Tahir et al., 2020)</td>
</tr>
<tr>
<td>Building Information</td>
<td>3D modelling and data integration technology can improve building projects.</td>
<td>(Demirdöğen et al., 2020; Evjen et al., 2020)</td>
</tr>
<tr>
<td>Modelling</td>
<td>efficiency, quality, and sustainability.</td>
<td>(Demirdöğen et al., 2020; Evjen et al., 2020)</td>
</tr>
<tr>
<td>Digital Twin</td>
<td>virtual representation of a physical asset and all the instances using real-time information.</td>
<td>(Akanmu et al., 2021; Madubuike et al., 2022; Madubuike and Anumba, 2023; Sampaio et al., 2023)</td>
</tr>
<tr>
<td>Internet of Things</td>
<td>network of physical objects embedded with sensors, software, and other technologies to collect and exchange data.</td>
<td>(Demirdöğen et al., 2020; Evjen et al., 2020; Tahir et al., 2020)</td>
</tr>
</tbody>
</table>

6.3 Stakeholder and Management support

This competency is on garnering support from stakeholders and management for successfully implementing and integrating AI and AIM technologies in healthcare facilities management. The functioning of healthcare facilities relies on cooperation with other stakeholders, such as suppliers, government, the public, caregivers, and patients (Li et al., 2021). Understanding the perspective of a group of stakeholders on achieving their desired objective and fostering effective communication and collaboration among these stakeholders is essential to align their efforts and ensure a shared understanding of the roadmap's objectives (Pantzartzis et al., 2019). Management generally refers to the decision-makers integrating innovative technology since they considerably affect the adoption process. AI deployment, for instance, implies considerable changes in financial investment and complicated processes in the healthcare industry. Therefore, it might be regarded a strategic move that demands strong managerial backing. Management's support directly influences the successful deployment of new AI technologies in healthcare companies (Lai et al., 2014).

By actively involving and considering the perspectives and needs of end-users and stakeholders throughout the process, this approach enables a comprehensive understanding of different aspects of the innovation. This inclusive approach fosters improvements in the innovation's design, implementation, and overall impact. By considering the input and feedback from end-users and stakeholders, the approach promotes the development of solutions that better meet their requirements and address their challenges. Ultimately, this user-centric approach enhances the effectiveness and success of the innovation by aligning it with the needs and perspectives of the end-users and stakeholders.
more closely with the needs and expectations of those who will benefit from it (Støre-Valen, 2021).

Li et al. (2021) discuss the importance of stakeholder and top management engagement in developing and implementing sustainable healthcare facilities. The article states that "stakeholder engagement is essential for the success of any sustainable healthcare facility project" and that "top management support is critical for ensuring that the project is given the resources and attention it needs.

However, the research was constrained to a limited number of countries, primarily developed ones, calling for more studies on sustainable healthcare facilities in developing nations. Additionally, the focus of research predominantly centres on environmental sustainability, warranting further exploration of sustainable healthcare facilities' social and economic dimensions. Furthermore, the reliance on case studies, while insightful, necessitates more quantitative research to assess the effectiveness of sustainable healthcare facilities.

In addition to the limitations and gaps, several other factors restrict the research on sustainable healthcare facilities. Outdated information poses a challenge, and the research often overlooks these facilities' social and economic implications, primarily focusing on technical aspects. Moreover, the research predominantly represents a Western perspective, failing to encompass the diverse implementation approaches of sustainable healthcare facilities worldwide.

Amos (2022) emphasised the importance of stakeholder and top management engagement in the performance measurement process. The article states that "stakeholder engagement is essential for the success of any performance measurement project" and that "top management support is critical for ensuring that the project is given the resources and attention it needs. The article identifies key stakeholders in the performance measurement process, including patients, staff, government agencies, and top management. It emphasises that top management support is critical to the project's success by setting goals, allocating resources, communicating importance, and providing visible support.

The article suggests involving stakeholders from the beginning to plan and design the performance measurement process. It emphasises the need for clear leadership and direction from top management and collaborative efforts between stakeholders and top management to overcome challenges and achieve goals. The research acknowledges several research limitations and gaps in the field. These include the reliance on a single case study, the need to consider the specific needs of different developing countries and the lack of consideration for the impact of the COVID-19 pandemic on FM services.

The research had its share of limitations and gaps. These include the reliance on a single case study, the limited consideration of specific needs across developing countries, and the lack of examination of the COVID-19 pandemic's impact on FM services. The study's limitations extend to the available data, as it was based on a single public hospital in Ghana, potentially limiting the generalizability of findings to other hospitals in the country or across developing nations. Additionally, the qualitative methodology employed in the study may have implications for the interpretation and application of the framework compared to alternative quantitative approaches.

6.4 Change Management

Proficiency in effectively managing organisational change associated with adopting and integrating AI and AIM technologies in healthcare facilities management. In healthcare organisations, implementing easier and more sustainable changes can have significant benefits, including the potential for culture change over time. Healthcare organisations can effectively overcome resistance and barriers by focusing on easier implementation changes. This can result in a smoother transition and greater acceptance of the changes among staff and stakeholders (Vaughn et al., 2019). According to Wanigarathna et al. (2019), implementation of AI in the AIM of healthcare facilities necessitates support from and changes within the entire organisation. It goes beyond simply adopting new technologies; it requires a holistic approach encompassing various aspects.
of the organisation.

6.5 Maintenance Management System

The core competency of a Maintenance Management System refers to the proficiency in implementing and utilising a Maintenance Management System (MMS) to optimise maintenance activities and enhance healthcare facilities management. Efficient maintenance management relies on two crucial elements: the effective administration of the maintenance department and the implementation of sound maintenance strategies. These factors play a vital role in ensuring the smooth functioning and success of the maintenance department (Hassanain et al., 2013). Maintenance managers continue to employ inadequate maintenance management procedures, negatively affecting facilities and their services. These managers prioritise reactive maintenance tasks over proactive ones, often neglecting clients’ satisfaction and the overall performance of the services (Enshassi and Shorafa, 2015).

Traditionally, maintenance management systems have primarily concentrated on improving the maintenance processes during a building's occupancy. However, it is important to note that the lack of consideration for maintainability during the project delivery period can contribute to the high costs associated with building maintenance. Many organisations do not have a systematic mechanism to address maintainability during the project planning and construction phases, which can significantly impact the maintenance management system’s overall effectiveness and efficiency (Marzouk and Hanafy, 2022).

Kamal et al., (2021) explored Building Information Modelling (BIM) in managing maintenance activities in healthcare settings. BIM offers improved asset management, increased efficiency, and better department communication. However, challenges include cost, data entry requirements, and training needs. The article predicts a more affordable and user-friendly future for BIM in healthcare maintenance. BIM-based systems can enhance infection control, patient safety, and regulation compliance. The article provides a comprehensive overview of the topic, covering the benefits, challenges, and prospects of BIM in healthcare maintenance.

7.0 FUTURE DIRECTIONS AND RESEARCH GAPS

Research gaps one significant research gap identified from the current study is the lack of detailed examination regarding the cost implications of implementing a building information modeling BIM based maintenance management system understanding the financial aspects of such adoption is crucial for healthcare facilities considering the implementation of this system as such the absence of this critical information constitutes a major research gap additionally the impact of BIM on the workflow of maintenance staff is another area that requires further exploration the current document does not delve deep into the potential effects of BIM on the daily tasks and processes of maintenance staff this gap suggests a need for further investigation on how BIM can transform and optimise maintenance processes including facets like task automation and resource allocation future directions given the identified gaps future research can take two primary directions firstly there is a need to investigate the financial aspects of BIM based maintenance management systems in a healthcare setting future studies could provide a more detailed understanding of the cost implications associated with the implementation of such systems this could involve conducting cost benefit analyses return on investment studies or economic impact assessments to provide a comprehensive understanding of the financial aspect secondly further research should be dedicated to examining the impact of BIM on the workflows of maintenance staff this could involve investigating how the introduction of BIM affects the execution of maintenance tasks the potential for task automation how resources are allocated and how overall efficiency can be improved these insights would enhance our understanding of BIM practical implications and its potential to revolutionise maintenance processes in healthcare facilities.
8.0 CONCLUSION

The systematic review undertaken in this study provides a comprehensive overview of the current state of interplay between artificial intelligence (AI), asset information management (AIM), and healthcare facilities management. The evidence is clear through the detailed examination of a myriad of studies and research works: the incorporation of AI and AIM into healthcare facilities management holds immense potential for a transformational shift in the sector. The symbiosis of AI and AIM presents a promising future for healthcare facilities management. With its advanced analytics and machine learning capabilities, AI can provide more accurate, detailed, and timely information. This leap in data handling and interpretation can enable healthcare professionals to make informed, data-driven decisions regarding facility maintenance and management. The ability of AI to predict potential issues before they occur is a powerful tool, allowing for proactive management. This proactive approach could significantly reduce downtime due to unexpected maintenance, thereby increasing the overall efficiency of healthcare service delivery.

In parallel, AIM is the backbone supporting and managing the vast amounts of data generated by modern healthcare facilities. It ensures that all necessary information, from inventory status to maintenance schedules, is easily accessible, up-to-date, and accurate. This wealth of information is critical for maintaining a safe, efficient, and high-functioning healthcare environment.

This promising landscape is not without its challenges. The integration of AI and AIM into healthcare facilities management must navigate complex issues, including the need for data standardisation, ensuring data privacy and security, and addressing ethical considerations. Furthermore, there is a clear need for more empirical studies investigating these technologies’ practical implementation and impact in various healthcare settings. The literature indicates a gap in this area, and future research could focus on practical applications and case studies to provide a clearer picture of the benefits and challenges of implementation.

The synergy of AI, AIM, and healthcare facilities management is an emerging field, offering numerous opportunities for groundbreaking research. This systematic review will stimulate further inquiry into this promising area, opening new avenues of exploration. The potential benefits – improvements in efficiency, safety, and patient outcomes – are significant.

The roadmap towards fully integrated, AI and AIM supported healthcare facilities management may be complex and fraught with challenges, but the potential rewards make this a journey worth undertaking. Researchers and practitioners are pivotal in shaping this future, and this review serves as a stepping stone in that direction.

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Barriers to Adopting Property Technology (PropTech) in Residential Property Valuation Practice in South Africa

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ABSTRACT

Purpose of this paper
The aim of this research was to identify the barriers to the adoption of property technologies (PropTech) to residential property valuation practice in South Africa.

Design/methodology/approach
Data was collected through the distribution of structured questionnaires to property valuers, estate agents, banks, and home insurance companies in Gqeberha, South Africa. The data were analysed utilising MS Excel and QuestionPro to generate descriptive statistics in the form of frequencies and mean scores (MSs).

Findings
The results indicate that the main barriers to the adoption of PropTech are the high costs of software and hardware, lack of technological skills, high complexity levels of selected property technology, and the lack of government support and policies for the selected property technologies.

Research limitations/implications (if applicable)
The study is based on a small sample, which may affect the generalisation of the findings to other regions.

Practical implications (if applicable)
The results highlighted the need to create an enabling framework to support the adoption of PropTech to improve performance. The integration of property technologies into the real estate curriculum is important to impart knowledge and skills to the graduates.
**What is the original/value of paper?** The research makes an important contribution to an emerging body of knowledge regarding the integration of property technologies in valuation practice. The results of the study can inform the necessary interventions required to enhance PropTech adoption in property valuation practice in South Africa and elsewhere.

**KEYWORDS:** Barriers, PropTech, Property valuation, South Africa
1. INTRODUCTION

Property technology (PropTech) is rapidly emerging in residential property valuation (Brown, 2018:14) and is changing how investors, tenants, and managers use, invest, and finance property (Souza et al., 2021:170). PropTech combines technology advances into the property sector (Brown, 2018:14). PropTech assists property businesses in gathering, interpreting data, and determining the value of properties in instant and real-time thereby contributing to the growth of the property sector (Godoy and Boyle, 2019:3). It enhances the calculation of property values thereby improving the services offered by the real estate sector. The benefits of technology to the valuation process are that it makes the valuation process quicker and more accurate as human error is reduced (Scheurwater, 2017:6). Accurate and precise property valuation is vital for mortgage lending, calculating capital requirements, and issuing covered bonds (Scheurwater, 2017:6).

Innovations such as building information modelling (BIM), artificial intelligence (AI), and drone technology have great potential to enhance property valuation practice. According to Vir (2021:1), AI can enhance valuation practice through the use of a predictive analysis algorithm. Drone technology can be used to enhance valuation practice through improved inspections, which can be conducted within a short period (Smith, 2015:65).

Despite the benefits of PropTech and a growing interest in adopting technologies in property valuation (Godoy and Boyle, 2019:3), its adoption for property valuation remains sub-optimal. Therefore, this study sought to close this gap and contribute to this body of knowledge by investigating the barriers to the adoption of PropTech in property valuation. The study (a) reviews extant literature relative to the barriers to adopting property technologies in property valuation practice and (b) uses an illustrative case study to present the perceptions of property valuation professionals in Gqeberha relative to barriers to the adoption of PropTech in residential valuation practice in South Africa.

The rest of the paper is organised as follows. Section 2 reviews the literature on the interface between PropTech and valuation practice, and the barriers to the adoption of property technologies and the property valuation practice. Section 3 describes the methodology adopted to collect data for the chapter. Section 4 presents and discusses the research findings. Section 5 concludes the paper and presents recommendations to enhance the adoption of property technologies in the residential property valuation sectors.

2. THE REVIEW OF RELATED LITERATURE

This section presents the theoretical background of the study relative to specific subject areas.

2.1 Property Valuation

Property valuation is a process of assessing a particular property's value based on location, condition, and other factors (Blackledge, 2017:25). According to Isaac (2002:4), property valuation is an exercise carried out by a professional valuer to provide an assessment of the capital value or income arising from property investment. In the majority of cases, property valuers seek to ascertain the market value of a property. The International Valuation Standards Council (2020:18) defines a market value as the estimated amount where an asset should be exchanged on the valuation date between a willing buyer and a willing seller in an arm's length transaction after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion.

Property valuation is important to the efficient functioning of the property market and the economy (Abidoye et al., 2021:344). Valuation exercises are important when operating a business as they influence the investment decisions of an organisation. A key concern in the industry is client dissatisfaction with property values established by valuers. In South Africa, Mthupha (2022:1) reports an instance where a
dissatisfied property owner objected to the property value set his property in the valuation roll of Ekurhuleni Municipality. The market value, as guided by a professional valuer, was R2.1 million, yet the Municipality valuation roll set it at R3.2 million. The adoption of technologies in property valuation may help to reduce such discrepancies.

2.2 PropTech in property valuation
According to PwC (2014:4), technology is disrupting the way business operates. The real estate industry is leveraging innovative technologies, changing from traditional to smart real estate (Kaur and Solomon, 2021:247). According to Brown (2018:17), PropTech consists of three main elements: information, transactions, and management/control. The main enablers for the technology drive in real estate are hardware and software development, mobile communication and connectivity, and the Internet, including mobile Internet (Brown, 2018:17). With the growth of technological applications, the management of information evolved from the paper-based system to electronic automated systems.

As highlighted by Cheloti and Mooya (2021:1), valuation inaccuracy is a major challenge in property valuation. Client influences, the absence of national standards, skill, experience, and judgement of valuers, and lack of familiarisation with the market are some of the factors contributing to property valuation inaccuracies (Babawale and Omirin, 2012:149). It is costly to obtain information about property due to its unique nature and location (Lee and Sasaki, 2018:1).

Emerging digital technologies such as blockchain, artificial intelligence, robotics, BIM, automated valuation models (AVM), and drone technology have great potential to improve valuation practice. Big data is anticipated to augment human expertise by reducing the time spent on data-related work (Du et al., 2014:25). According to Kok (2020:1), AVM leverages various types of data like property age, listings, and conditions and generates a report within a short period. In Botswana, an automated property valuation Gosmartvalue at Vantage Properties supports decision-making by opening up critical information on real estate, such as land rates and sales trends (Churu, 2021). Clients are able to obtain self-service valuation reports and traditional valuation reports that are in detail (Churu, 2021).

Drone technology is an unmanned aerial vehicle or an aircraft with the capacity to fly autonomously due to the support of board computers and sensors (Smith, 2015:292). Drone technology is used by valuers to assist in field inspection, which makes the valuation practice quicker. For example, drones can be used where inspection is expected to cover larger pieces of land within a short time. Valuers are able to use drones to measure properties precisely as the laser scanner will be attached to them (Mohammed and Bello, 2021:66).

2.3 Barriers to the adoption of property technologies
While the benefits of technological innovations and the adoption of PropTech are evident, there are many barriers to adopting these technologies (Ullah et al., 2021:4). Table 1 presents a summary of the barriers to proptech adoption for property valuation.
References

High costs of software and hardware
- Babajide et al. (2018:63); Junior et al. (2017:36); Shenoy (2019:75)

Lack of government support and policies for property technologies
- Olaniyan (2019:45)

Lack of transparency of data sources and their use in the background
- Xu et al. (2021:5)

Limited knowledge of property technologies
- Xu et al. (2021:5)

High complexity levels of selected property technology
- Shenoy (2019:75)

Deficiency of management and lenders' trust in innovation and new technology
- Xu et al. (2021:5); Saari et al. (2022:5)

Lack of technological skills
- Narang (2020:1); Xu et al. (2021:5)

Lack of flexible organisational strategies supporting tech innovation
- Saari et al. (2022:5)

Lack of information on technology enhancing productivity
- Saari et al. (2022:5)

The unwillingness to shift from human intermediaries to ICT intermediaries
- Shenoy (2019:75); PwC (2017:1)

Lack of legal frameworks that support the adoption of property technology
- Olaniyan (2019:45)

Lack of trust in outsourcing organisational data
- Saari et al. (2022:5)

Lack of tangible information on the benefits of the selected technology
- Babajide et al. (2018:63); Junior et al. (2017:36)

Lack of coordination and cooperation among stakeholders
- Alderson (2020:1)

Cybersecurity fears by the organisation
- Alderson (2020:1)

Standardised digital data
- Babajide et al. (2018:63); Junior et al. (2017:36)

Lack of digital communication skills
- Alderson (2020:1)

3. RESEARCH METHOD

The research was conducted in two stages. First, extant literature was reviewed to identify the barriers to adopting property technologies in the property valuation practice. Second, an empirical study was conducted in Gqeberha to explore the perceptions of property valuation professionals relative to the barriers to adopting property technologies in the residential property valuation industry. The research was informed by the positivist worldview. A quantitative research approach was adopted, which entailed the distribution of one hundred and forty-eight (148) structured questionnaires to property valuation professionals in Gqeberha. Quantitative research was adopted because it allows numerical measurement of variables by using acceptable measures such as questionnaires and rating scales (Leedy and Ormrod, 2016).

Purposive sampling was used to select the real estate professionals who participated in the survey. The questionnaire was structured into two sections. Section A collected respondents' demographic data such as education, designation, and work experience. In Section B, the questionnaire collected respondents' perceptions regarding the effect of selected barriers on the adoption of proptech in residential property valuation. The barriers included in the questionnaire were generated from the literature, as shown in Table 1. A 5-point Likert type scale was adopted where, 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. A web-based questionnaire was distributed to valuation professionals through the assistance of the South African

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
Institute of Valuers (SAIV) and the South African Council for the Property Valuers Profession (SACPVP), who served as gatekeepers and agreed to use their websites to share the questionnaire link to their members. Prior to distributing the questionnaire, it was pilot-tested on three property valuation professionals to assess the clarity of questions and to identify any errors (Leedy and Ormrod, 2016). The comments received from the pilot survey were used to improve the final questionnaire distributed. The data were analysed using Microsoft Excel and QuestionPro to produce descriptive statistics, such as the calculation of frequencies, percentages, and a measure of central tendency in the form of a mean score (MS).

4. RESEARCH FINDINGS

4.1 Demographic profile of respondents
The study involved a sample size of 148 real estate professionals in Gqeberha, wherein 120 potential respondents viewed the online survey. Of the 120 who viewed the survey, 79 (65.83%) did not attempt to respond, 35 (29.17%) completed the questionnaire, and 6 (5%) dropped out. Although most respondents did not provide any reasons for dropping out, one respondent cited organisational responsibilities as the cause. Consequently, the researcher received 35 fully completed questionnaires. Although the sample is small, it exceeded the minimum threshold of 30 required for statistical analysis to be conducted (O'Leary).

The completed questionnaires were received from property valuers (57.1%), estate agents (28.9%), general managers (8.6%), managing directors (2.9%), and others (2.9%). The respondents' work experience spanned from 1 year to more than 30 years, and most of the respondents had 11 to 15 years (34.0%) of experience. The qualifications of the respondents include a Diploma (54.0%), Bachelor's Degree (34.0%), Master's Degree (6.0%), PhD (3.0%), and other (3.0%). The demographic analysis indicates that the respondents had relevant experience and knowledge to provide valid and reliable assessments of the issues raised in the questionnaires. However, given the small sample size, the results can be considered indicative.

4.2 Barriers to technology adoption in residential valuation practice
Table 2 presents the respondents' assessment of the barriers to the adoption of property technologies in terms of percentage responses to a scale of 1 (strongly disagree) to 5 (strongly agree) and a mean score (MS) ranging between 1.00 and 5.00, the midpoint score being 3.00. The results show that all the MSs are ≥ 3.00, indicating that respondents agree as opposed to disagreeing that the selected barriers inhibit the adoption of property technologies.
Table 2: Barriers to the adoption of property technologies

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Responses (%)</th>
<th>MS</th>
<th>SD</th>
<th>Overall ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U 1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High costs of software and hardware</td>
<td>0.0 3.0 0.0 6.0 57.0 34.0</td>
<td>4.20</td>
<td>0.81</td>
<td>1</td>
</tr>
<tr>
<td>Lack of technological skills</td>
<td>0.0 0.0 9.0 23.0 46.0 23.0</td>
<td>3.83</td>
<td>0.82</td>
<td>2</td>
</tr>
<tr>
<td>High complexity levels of property technologies</td>
<td>0.0 0.0 6.0 20.0 63.0 11.0</td>
<td>3.80</td>
<td>0.80</td>
<td>3</td>
</tr>
<tr>
<td>Lack of government support and policies for the adoption of property technologies</td>
<td>3.0 3.0 11.0 26.0 34.0 23.0</td>
<td>3.54</td>
<td>1.22</td>
<td>4</td>
</tr>
<tr>
<td>Limited knowledge of property technologies</td>
<td>3.0 0.0 6.0 34.0 51.0 6.0</td>
<td>3.49</td>
<td>0.95</td>
<td>5</td>
</tr>
<tr>
<td>Lack of transparency of data sources and its use in the background</td>
<td>3.0 6.0 9.0 20.0 49.0 14.0</td>
<td>3.49</td>
<td>1.07</td>
<td>6</td>
</tr>
<tr>
<td>Deficiency of management and lenders’ trust in innovation and new technology</td>
<td>6.0 3.0 11.0 17.0 46.0 17.0</td>
<td>3.46</td>
<td>1.27</td>
<td>7</td>
</tr>
<tr>
<td>Lack of flexible organisational strategies supporting tech innovation</td>
<td>0.0 11.0 6.0 20.0 51.0 11.0</td>
<td>3.46</td>
<td>1.14</td>
<td>8</td>
</tr>
<tr>
<td>Lack of tangible information on the benefits of the selected technology</td>
<td>0.0 11.0 6.0 23.0 46.0 14.0</td>
<td>3.46</td>
<td>1.09</td>
<td>9</td>
</tr>
<tr>
<td>Resistance to shift from human intermediaries to ICT intermediaries</td>
<td>6.0 3.0 9.0 29.0 37.0 17.0</td>
<td>3.40</td>
<td>1.24</td>
<td>10</td>
</tr>
<tr>
<td>Lack of information on technology enhancing productivity</td>
<td>0.0 6.0 11.0 34.0 40.0 9.0</td>
<td>3.34</td>
<td>1.01</td>
<td>11</td>
</tr>
<tr>
<td>Lack of trust in outsourcing organisational data</td>
<td>3.0 3.0 17.0 23.0 43.0 11.0</td>
<td>3.34</td>
<td>1.12</td>
<td>12</td>
</tr>
<tr>
<td>Lack of digital communication skills</td>
<td>0.0 6.0 11.0 34.0 43.0 6.0</td>
<td>3.31</td>
<td>0.95</td>
<td>13</td>
</tr>
<tr>
<td>Cybersecurity fears by the organisation</td>
<td>3.0 6.0 11.0 29.0 43.0 9.0</td>
<td>3.29</td>
<td>1.10</td>
<td>14</td>
</tr>
<tr>
<td>Lack of coordination and cooperation among stakeholders</td>
<td>0.0 6.0 17.0 31.0 40.0 6.0</td>
<td>3.23</td>
<td>0.94</td>
<td>15</td>
</tr>
<tr>
<td>Lack of standardised digital data</td>
<td>3.0 0.0 23.0 29.0 40.0 6.0</td>
<td>3.20</td>
<td>1.04</td>
<td>16</td>
</tr>
<tr>
<td>Lack of legal frameworks that support the adoption of property technology</td>
<td>3.0 9.0 23.0 20.0 40.0 6.0</td>
<td>3.03</td>
<td>1.14</td>
<td>17</td>
</tr>
</tbody>
</table>
The results indicate that the barriers ranked 1 to 9 have MS > 3.40 ≤ 4.20, which indicates that the respondents agree that these factors limit the adoption of property technologies.

Overall, the results presented in Table 2 suggest that the ‘high cost of software and hardware’ (MS = 4.20) is the leading barrier to the adoption of property valuation technologies. The results corroborate the generally high cost of information communication technologies, gadgets, and software in developing countries. This result corroborates Babajide et al. (2018:63), whose study identified the cost of ICT packages as one of the barriers to adopting technology in the real estate industry. Narang (2020:1) alluded that the real estate industry faces resource challenges concerning adopting Proptech because of the lack of tech talent and a huge IT infrastructural cost.

The 2nd ranked factor is 'lack of technological skills'. This may be attributed to the inadequate integration of digital technology in the real estate curriculum. During a related study, Xu et al. (2021:5) identified a lack of information technology (IT) infrastructure, knowledge and expertise among organisational barriers affecting the adoption of technology.

The respondents ranked ‘high complexity levels of selected property technology’ 3rd among the factors inhibiting the adoption of property technology in valuation practice. This finding is consistent with Xu et al. (2021:5) that organisational barriers such as the lack of information technology (IT) infrastructure, knowledge and expertise, and trust among stakeholders affect the adoption of Proptech. During another related study, Babajide et al. (2018) identified difficulty in the operation of some programmes as a major factor inhibiting the adoption of ICTs in real estate in Nigeria.

The 4th ranked factor is 'lack of government support and policies to adopt property technologies' (MS = 3.54). As in other sectors, government support and the availability of enabling policy frameworks are required to facilitate the transition to the adoption of technology in the built environment. The finding highlights the need for government to come up with appropriate policies that support technology adoption in the sector. Notably, the finding is consistent with Olaniyan (2019:45) wherein lack of government policies and functioning regulatory agencies was identified as one of the major barriers affecting the adoption of IT in construction and real estate firms in Nigeria.

The 5th ranked factor is ‘limited knowledge of property technology’. The results impress on the need for knowledge relative to the various technologies, which can be applied to property valuation. Accordingly, institutions of higher learning and property valuation institutions have an obligation to educate real estate practitioners relative to the technologies. The results reinforce the findings of past studies. Xu et al. (2021:5) identified lack of knowledge and expertise as important factors inhibiting technology adoption in real estate practice.

The factors ranked 10th to 17th have MS > 3.00 ≤ 3.40, which suggests that respondents concur between neutral and agreeing that 'the unwillingness of shifting from human intermediaries to ICT intermediaries', 'lack of information on technology enhancing productivity', 'lack of trust in outsourcing organisational data', 'lack of digital communication skills', 'cybersecurity fears by the organisation', 'lack of coordination and cooperation among stakeholders', 'lack of standardised digital data', and 'lack of legal frameworks that support the adoption of property technology' inhibit the adoption of Proptech in property valuation practice in Gqeberha, South Africa.

5. CONCLUSIONS AND RECOMMENDATIONS
The study sought to establish the barriers to technology adoption in residential valuation practice. The study established that seventeen barriers affect technology adoption in valuation practice. The top five barriers include...
the high costs of software and hardware, lack of technological skills, high complexity levels of property technology, lack of government support and policies for the selected property technologies, and limited knowledge of the property technologies. The results highlight the need to deepen investment in knowledge development and digital skills upgrading. In addition, the results further highlight the need to create an enabling environment to reduce the cost of hardware and software relative to Proptech. The study recommends the need to integrate Proptech into the real estate curriculum.

Although the study makes an important contribution to the existing body of knowledge by providing important insights into the barriers to the adoption of technology in valuation practice, the small sample size calls for caution when generalising the results to other geographical regions.

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Equitable Risk Sharing in South African Construction Projects during Exceptional International Events

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ABSTRACT
Purpose of this paper
This research aims to examine the equitable sharing of financial risk between employers and contractors in the context of exceptional international events.

Design/methodology/approach
The research methodology is qualitative, and data was gathered through semi-structured interviews, using a non-probabilistic purposive sampling technique. Thematic data analysis was employed to analyse the collected data, involving transcription, familiarization, coding, and theme development.

Findings
The findings highlight the importance of contractual provisions that address the specific financial risks associated with exceptional events, going beyond traditional force majeure clauses. Collaborative efforts and effective risk management strategies are recommended to ensure a fair allocation of losses.

Practical implications
The paper offers practical implications, including the development of comprehensive risk management plans and the establishment of clear contractual provisions. By addressing the gaps in existing literature, this study provides valuable insights into risk sharing dynamics, helping stakeholders mitigate financial vulnerabilities and enhance project resilience in the face of global disruptions like the COVID-19 pandemic and the Russia-Ukraine invasion.

What is the original/value of paper?
The research landscape on risk sharing concerning financial risks arising from exceptional international events remains limited. This study offers insights into the unique dynamics of risk sharing in construction projects in South Africa, thereby assisting stakeholders in mitigating financial vulnerabilities and enhancing project resilience.

Keywords: Exceptional International Events; Equitable Risk Sharing; Construction Projects; COVID-19; Russia-Ukraine War.
1. INTRODUCTION

In an era characterized by increased dynamism, turbulence, and unpredictability on a global scale, the frequency of exceptional international events, ranging from natural disasters and terrorism to economic recessions, mass migrations, cyber threats, and epidemics, has witnessed a substantial surge (Wang, et al., 2023; You & Williams, 2023). The occurrence of exceptional international events has the potential to significantly impact all industries. The construction industry, like other sectors, is not immune to the profound effects of exceptional international events. Notably, recent occurrences such as the global COVID-19 pandemic and the invasion of Ukraine by Russia have had significant repercussions on construction projects, introducing unforeseen financial risks that jeopardize their success and viability (Development Bank of Southern Africa, 2022). These unforeseen financial risks have the potential to disrupt the delicate equilibrium of financial risk sharing between employers and contractors, often leaving one party disproportionately vulnerable to the adverse consequences.

The South African construction industry is no stranger to the repercussions of exceptional international events. The country's construction industry has been marked by its capacity to grow due to increased infrastructure investment (Development Bank of Southern Africa, 2022), yet it remains vulnerable to the consequences of external shocks. This is attributed to the nature of the construction industry which makes it prone to factors such as unpredictability, fragmentation, sensitivity to economic cycles, and competitiveness (Choi, et al., 2018). Furthermore, construction projects are inherently exposed to a multitude of risks due to factors such as substantial costs, intricate interfaces, diverse stakeholders, integration of materials and technologies, and stringent time constraints (Guo, et al., 2014). The COVID-19 pandemic, for instance, has had a profound impact on construction projects, causing disruptions in material supply chains, labour shortages, and regulatory changes, all of which have presented unprecedented challenges for both employers and contractors (Aigbavboa, et al., 2022).

The equitable allocation of risk is a fundamental aspect of construction contracts, ensuring that parties assume responsibility for the risks they are best positioned to manage (Peckiene, et al., 2013; Andi, 2006; Perez, et al., 2017; Mead, 2007). However, the allocation of risk in construction projects is frequently assigned without due consideration to the party who possess the most effective control capabilities (Sharkey, et al., 2014). Furthermore, in the face of exceptional international events, the traditional risk-sharing mechanisms may prove inadequate, as the magnitude and nature of these events often exceed the reasonable expectations of the contracting parties (Yadeta & Pandey, 2020). Disputes, faults, and delays in construction projects have been attributed to the identification of unfair or unbalanced risk allocation (Love, et al., 2008). Despite the cited importance of equitable risk sharing in construction projects, literature related this topic in relation to exceptional international events is scarce. Consequently, a critical question arises: How can construction contract parties equitably share the financial risk arising from exceptional international events?

This research aims to examine the complex issue of equitable risk sharing in construction projects in South Africa in the context of exceptional international events. By analysing the existing legal frameworks, industry practices, and contractual arrangements, this study seeks to identify strategies and mechanisms that can promote fair and effective risk sharing, ultimately enhancing the resilience of construction projects in the face of unforeseen events.

The findings of this research have significant implications for construction stakeholders, including employers, contractors, policymakers, and industry regulators. By shedding light on equitable risk sharing practices, this study offers insights into the unique dynamics of risk sharing in construction projects in South Africa, thereby assisting stakeholders in mitigating financial vulnerabilities and enhancing project
resilience. The subsequent sections of this paper provide a comprehensive review of existing literature pertaining to the factors that contribute to inequitable risk allocation in various contexts. The research methodology employed in this study is then outlined, followed by the presentation and discussion of the findings obtained from the analysis.

2. LITERATURE REVIEW

The literature review explores the existing research on equitable financial risk sharing between employers and contractors in the context of construction projects, particularly in the presence of exceptional international events. By analysing the key determinants, challenges, and potential solutions identified in the literature, the literature review provides a comprehensive understanding of the current state of risk allocation practices and highlights avenues for achieving a balanced and equitable approach in the face of unforeseen events.

2.1 The impacts of exceptional international events on construction contract risk

Exceptional international events, such as natural disasters, terrorism, global economic recessions, epidemics, pandemics, war, invasions, etc have been recognized as significant disruptors in the construction sector (Aigbavboa, et al., 2022; Amri, 2021; Boyette, 2022; Gajdosikova, et al., 2022). In this study we contextualise exceptional international event as significant occurrences or incidents that transpire on a global scale and have wide-ranging impacts beyond the borders of a single country. The exceptional nature of these events arises from their magnitude, scope, and the potential to cause significant disruptions and challenges to various aspects of society, including economic, social, and political systems. The COVID-19 pandemic as well as the recent invasion of the Ukraine by Russia serve as examples of such exceptional international events which had unprecedented adverse impacts on construction projects.

2.1.1 The impact of Covid-19 on the construction industry

The COVID-19 pandemic, which emerged in Wuhan, China, in December 2019, has had far-reaching consequences on multiple industries worldwide, including construction, manufacturing, property, travel, and aviation (World Health Organisation, 2020). As a result of the pandemic, along with the other industries, the construction industry experienced significant disruptions and varying degrees of impact (Nair & Suresh, 2021). The COVID-19 pandemic adversely affected the global economy, resulting in challenges related to labor availability, efficiency, project timelines, and increased production costs (Aigbavboa, et al., 2022; Khalef, et al., 2022). Construction projects had to be suspended or closed globally, impacting families, companies, and financial institutions (Iqbal, et al., 2021).

The global construction industry's contribution to GDP saw a decline due to the adverse effects of the COVID-19, with the growth of the global construction industry decreasing from 3.1% to 0.5% (Worldwide Information, 2020). In response, construction companies have been actively seeking strategies to mitigate the short- and long-term repercussions of the pandemic on their operations (Aigbavboa, et al., 2022). Notably, the Indian construction industry experienced a substantial contraction, with an expected decline of around 40% (Nair & Suresh, 2021). In Oman, the construction industry has been significantly affected by the COVID-19 pandemic, resulting in reduced government support for development projects due to the decline in oil production (Amri, 2021). Consequently, there have been reduced subsidies and financing assistance for construction projects.
Supply chain disruptions have emerged as a key challenge, leading to significant delays in the procurement of construction materials. Moreover, the construction of COVID-19 isolation facilities has further strained the demand for building materials (Hong, 2021). Contractors, burdened with high debts and limited cash reserves, have faced liquidity challenges, while subcontractors have encountered difficulties in adapting to the economic consequences (Amri, 2021). Contractual issues and terminations have also emerged as prominent concerns, resulting in project delays and significant financial implications. Economies worldwide are bracing for substantial declines, with projections of up to 15% (Aigbavboa, Thwala, & Ngozwana, 2021). Financial hardships resulting from the pandemic have further exacerbated project delays and compromised material quality, as contractors grapple with meeting loan and credit commitments (Nair & Suresh, 2021). In Oman, the construction industry heavily relies on materials sourced from various locations, leading to supply chain disruptions and escalated supplier costs (Amri, 2021). These disruptions, coupled with contractual implications, have had a profound impact on project schedules, resulting in substantial losses for both construction organizations and suppliers. Additionally, business closures and factory shutdowns have further aggravated the challenges faced by the construction industry (Biswas, et al., 2021).

2.2 The impact of the Russia-Ukraine invasion on the construction industry
In February 2022, Russia initiated a military invasion of Ukraine, coinciding with the ongoing COVID-19 pandemic and under the direction of Russian President Vladimir Putin (Boyette, 2022). This conflict has resulted in extensive sanctions imposed on Russia, targeting various sectors of its economy, as well as its political and military leaders. The crisis in Ukraine is projected to reverberate globally, particularly in Europe, as it amplifies the urgency to mitigate the impact of supply chain disruptions caused by pandemics, events like the Suez Canal blockade, and other destabilizing factors (Weinfass, 2022).

Within the construction industry, a range of challenges were experienced, including escalating production costs, project delays, and labour shortages. In South Africa, the construction industry confronted challenges stemming from rising prices and material scarcity, exacerbated by the unpredictable nature of international events and conflicts (Bulbulia, 2022). Similarly, in the United Kingdom, building projects encountered uncertainties arising from limited availability and increased costs of critical materials, alongside high energy prices that exert additional financial strain on energy-intensive projects. Moreover, shipping costs are anticipated to rise, further complicating the landscape for the construction sector (Duncan & McEvoy, 2022).

2.3 Sharing of financial risk between the contractor and employer
The construction industry inherently involves risks, including escalating costs and fluctuating material expenses (Guo, et al., 2014). Accurate identification and proficient management of risks are paramount for achieving project success (Harinarain & Othman, 2007; Perez, et al., 2017). Contractors must remain vigilant regarding their contractual obligations and associated risks to ensure successful project outcomes (Peckiene, et al., 2013). Equitable financial risk sharing between contractors and employers is a crucial aspect of construction contracts (Love, et al., 2008; Andi, 2006). Achieving a fair distribution of financial risks can contribute to a balanced and sustainable project environment (Yadeta & Pandey, 2020).

Osipova & Eriksson (2011) identified three fundamental factors for determining risk allocation in construction projects as contract type, payment structure, and risk management. KarimiAzari, et al. (2011),
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content that risk assessment is the most important factor when in the risk management process. On the other hand, Andi (2006) argues that the elimination of construction risks is a challenging endeavour as they inherently exist within the industry. Andi (2006) proposes that the focus lies in effectively managing these risks by transferring or sharing them between parties through contractual provisions.

Additionally, the effectiveness and efficiency of contract clauses can only be fully comprehended when both contracting parties share a mutual understanding of risk allocation and assume accountability for risk management (Andi, 2006). In the absence of clear contractual provisions, disagreements may arise regarding the assignment of risk responsibility, potentially leading to the mishandling of risks as parties mistakenly believe they are not accountable for certain risks or their consequences. Such mismanagement of risks can result in project inefficiencies and strain the contractual relationships, ultimately leading to an escalation in project costs (Hartman & Snelgrove, 1996). This approach acknowledges the reality of construction risks and emphasizes the importance of contractual mechanisms for their effective management.

2.4 Force Majeure clause implications for exceptional international events

In the realm of construction contracts, the concept of force majeure, as applied in law, pertains to a contractual provision that releases a party from fulfilling its contractual obligations in cases where the performance of the contract is hindered by natural or unavoidable circumstances (Salami, et al., 2023). Furthermore, Salami, et al. (2023) state that force majeure events are considered exceptional events that are beyond the control of the contracting parties and hinder the execution of construction contracts either physically or legally.

In the construction industry, force majeure clauses are often relied upon by contractors seeking time extensions for project delays. However, these clauses typically do not provide financial compensation for the financial costs attributable to the force majeure. Current methods for analysing force majeure claims often overlook the impact of other delays and factors, necessitating a more comprehensive approach (Alshammari, et al., 2017). (Cliffe Dekker Hofmeyr, 2020) argue that the stringent requirements for a successful force majeure claim often fail to provide both time extensions and financial compensation, posing challenges for contractors. Moreover, given the exceptional nature of events like the COVID-19 pandemic and the invasion of Ukraine by Russia, there is a need to review and revise construction project laws, particularly those pertaining to government action or inaction, to ensure adequate cost relief for affected projects. The current clauses present obstacles to making fair force majeure claims, highlighting the importance of revisiting and updating contractual provisions (Cliffe Dekker Hofmeyr, 2020).

Legal conflicts and disputes have arisen within the construction industry regarding the effect of exceptional international events, including the COVID-19 pandemic (Husein, et al., 2021). Contractors are finding it challenging to fulfil contractual obligations and access necessary resources, resulting in costly project delays and cancellations (Husein, et al., 2021). Furthermore, contractors face legal challenges related to profit margins, increased costs, safety conditions, tax issues, and other factors. Flexibility in legal terms and standard contract revisions have been explored as potential solutions to navigate these challenges (Salami, et al., 2023). It is necessary to revise standard contracts to include global pandemics as force majeure events, and governments should provide support to contractors through measures such as COVID-19 testing, amending health and safety regulations, and fair tax policies (Husein, et al., 2021; Larasati, et al., 2021).
3. METHODOLOGY

This study employed a qualitative research approach to gain in-depth insights into the experiences and perspectives of construction professionals regarding equitable sharing of financial risks that arise as a result of exceptional international events. A qualitative approach was used as it offers a more open perspective through using diverse data and evidence while discovering new issues (Neuman, 2003). The research methodology encompassed semi-structured interviews as the primary data collection method and thematic data analysis for data interpretation.

A non-probabilistic purposive sampling technique was utilized to select participants for this study. The sample comprised 11 construction professionals, including 2 construction lawyers, 5 consulting quantity surveyors, and 4 contractor’s representatives, who possessed extensive experience and expertise in construction law and were involved in construction projects during the COVID-19 pandemic and the invasion of the Ukraine by Russia. The selection of participants was guided by the aim of capturing a diverse range of perspectives and ensuring representation across various roles within the construction law field. Semi-structured interviews were conducted as the main data collection method. The semi-structured nature of the interviews allowed for a flexible yet focused approach, enabling participants to express their viewpoints and experiences in-depth (McIntosh & Morse, 2015). The interview guide consisted of a set of open-ended questions developed based on the research objectives and prior literature review. The interviews were for a duration of 1 hour and conducted virtually via Microsoft Teams, ensuring a conducive environment for participants to freely share their insights. Thematic data analysis was employed to analyse the collected data. This approach involved several interconnected stages. Initially, the interview recordings were transcribed verbatim to ensure accurate representation of participants’ responses. Next, a process of familiarization with the data was undertaken to gain a comprehensive understanding of the content. Subsequently, initial codes were generated, identifying meaningful segments and patterns within the data. These codes were then organized into higher-order themes, capturing overarching concepts and ideas that emerged from the dataset. The analysis process involved constant comparison and refinement of themes, ensuring the robustness and credibility of the findings.

4. FINDINGS AND DISCUSSION

The discussion of results section focuses on the findings of the study by presenting the key themes that emerged from the data analysis and provides insights into the financial impact of exceptional international events on construction projects. The discussion highlights the effects of these events on contractors, the need for improvements in standard forms of contracts, and the role of the force majeure clause in addressing financial risks. By exploring these themes, the discussion aims to contribute to a deeper understanding of equitable risk sharing and provide practical implications for stakeholders in the construction industry.

Profile of respondents

The distribution of study participants across different disciplines provides a nuanced perspective on the research landscape. Table 1 presents a summary of the disciplines of the respondents.
The financial impact of exceptional international events

The majority (90.9%) of respondents concurred that exceptional international events exert a significant financial impact on construction projects. Economic factors, such as fuel prices, have a profound influence on the construction industry, leading to fluctuations in living costs and project expenses. Projects reliant on imports are especially susceptible to the effects of these events. Consequently, contractors often find themselves claiming standing time, while employers must revise their budgets and allocate additional funds to projects in response to these challenges. Furthermore, contractors have had to request compensation for various expenses related to COVID-19, further straining employers' financial resources.

The Russian-Ukraine conflict, for instance, has caused diesel price hikes, asphalt cost fluctuations, supply difficulties from Russia, and a general surge in fuel prices. The resultant increase in oil prices directly impacts construction projects, particularly in terms of steel scarcity. As a result, companies have had to source steel from larger corporations, leading to delays in project timelines. Disruptions in the materials supply chain have resulted in significant price fluctuations, standing time costs for machinery, and material deterioration on-site. Moreover, COVID-19 has dictated production rates, with contractors forced to adhere to strict protocols.

This study’s findings underscore the substantial financial repercussions that exceptional international events impose on employers and contractors engaged in South African construction projects. These findings align with the impacts documented by Gajdosikova, et al. (2022) concerning the challenges posed by COVID-19 in the construction sector. These challenges encompass prolonged contract durations, unexpected variations leading to time and cost overruns, necessitating additional funds and surpassing budgeted contingencies. The findings also corroborate the price increase phenomenon observed by Amri (2021), indicating that South Africa experienced price hikes in oil, fuel, and building materials, including steel. Contractors grappled with adapting to new protocols, complying with safety measures, and facing increased expenses for personal protective equipment. Insurance costs escalated, and work completion claims were delayed during lockdowns. These exceptional international events have made procuring goods and managing escalating costs challenging, rendering both employers and contractors financially vulnerable.

The force majeure clause

The research study investigates the application of standard contract forms in the context of exceptional international events, with a specific focus on the Force Majeure Clause. The study findings reveal that while the Force Majeure Clause, commonly found in construction contracts, attempts to address exceptional international events, it inadequately addresses their financial implications. While the clause grants a time extension to parties unable to perform due to exceptional events, it falls short in addressing the associated financial losses comprehensively. Notably, the clause...
primarily shields employers from financial burdens, placing contractors at a higher financial risk. This imbalance underscores the need for a more equitable approach to distributing financial risk, ensuring the protection of both employers and contractors. As noted by Salami et al. (2021), existing Force Majeure Clauses are considered insufficient in effectively responding to exceptional international events. Regarding the current use of standard contract forms, the study reveals variations in their treatment of Force Majeure events. In JBCC contracts, all such events are classified as Force Majeure, granting contractors a time extension but not additional costs. FIDIC offers time protection for contractors, especially if the event occurs within the country. In contrast, GCC and NEC contracts address both time and cost aspects, but they inadequately cover material cost increases. The study underscores that Force Majeure clauses do not explicitly address the financial ramifications of exceptional international events. While Force Majeure is commonly invoked in claims, its primary function is to absolve parties from blame rather than stipulating financial consequences.

**Improvements to the construction standard forms of contracts**

Jones (2021) argues that current contractual provisions for exceptional events in construction contracts are often inadequate, resulting in uncertainty and potential disputes. This study reinforces Jones’ argument and underscores the necessity for substantial improvements in standard construction contracts to effectively address exceptional international events. Achieving a fair distribution of risk necessitates open discussions and compromises among involved parties.

To enhance standard contract forms, participants recommend the inclusion of specific clauses tailored to address exceptional international events. These clauses should be mutually beneficial and clearly articulated in writing to eliminate ambiguity. Participants prefer precise clauses over broad ones and emphasize the importance of considering how financial risks are distributed within the Force Majeure clause.

It is emphasized that parties should mutually agree to incorporate such clauses into existing contracts, given the persistent uncertainty surrounding exceptional international events. Effective communication and negotiation, extending beyond the contract terms, are deemed essential for maintaining a constructive working relationship between parties. Additionally, participants propose practical strategies like identifying special materials and implementing a rise-and-fall pricing mechanism to mitigate the impact of price fluctuations.

In conclusion, the results discussion provides valuable insights into the financial repercussions of exceptional international events in construction projects. These findings underscore the pressing need for comprehensive improvements in standard contract forms, particularly in addressing financial risks and achieving equitable risk distribution. The study underscores the significance of incorporating specific provisions, enhancing the Force Majeure clause, and establishing clear mechanisms for addressing cost increases and uncertainties arising from exceptional events. By embracing these recommendations, stakeholders in the construction industry can navigate future exceptional international events more effectively, mitigate financial vulnerabilities, and foster a more balanced and sustainable project environment.

5. **CONCLUSIONS**

5.1 **Research summary**
This study sought to examine how the financial risks arising from exceptional international events can be equitably shared between the employer and the contractor. The findings have revealed the limitations of existing standard form contracts in providing adequate remedies and addressing the uncertainties associated with these events. It is evident that the distribution of financial risk needs adjustment, with a shared responsibility between the contracting parties rather than a one-sided burden. To address this, several recommendations have emerged from the study. Firstly, the inclusion of additional clauses in contracts specifically addressing price and cost rises caused by exceptional international events is recommended. This would provide a more proactive and comprehensive approach to risk allocation. Secondly, employers should be open to dialogue and willing to consider provisions that address the potential for increased expenses resulting from future events. This collaborative approach would ensure a fair and balanced risk-sharing mechanism. Additionally, setting aside funds for unforeseen circumstances can further contribute to maintaining a stable and resilient project environment. By implementing these recommendations, construction contracts can better address the financial risks associated with exceptional international events, leading to improved project outcomes and enhanced sustainability.

5.2 Research limitations
It is important to acknowledge certain limitations of this study. Firstly, the sample size was relatively small, comprising 11 construction professionals. While efforts were made to select participants with diverse backgrounds, the findings may not be generalizable to the entire population of construction professionals. Additionally, the study focused solely on semi-structured interviews as the data collection method, and other sources of data, such as document analysis or observations, were not included. These limitations should be considered when interpreting the results and applying them to broader contexts. Despite these limitations, this research methodology provided valuable insights into the experiences and perspectives of construction professionals, offering a nuanced understanding of equitable risks arising from exceptional international events.

5.3 Recommendations and future research
There are two recommendations for future research. Firstly, exploring the perspectives of employers on equitable risk sharing during exceptional international events would provide a comprehensive understanding of their role and viewpoints. Additionally, supplementing qualitative findings with quantitative research to assess the financial implications on construction projects, such as cost overruns and delays, would enhance the understanding of equitable risk sharing. By addressing these areas, future research can contribute to the development of more effective risk management strategies and improved project outcomes.

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Challenges affecting the adoption of Industry 4.0 technologies in enhancing construction project delivery in Zimbabwe.

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ABSTRACT

Purpose/Background
The limited use of modern technology in the Zimbabwean construction industry due to numerous challenges is leading to unsuccessful construction project delivery in terms of low-quality administration, poor health and safety performances, and time and cost overruns. Therefore, the objective of the study was to investigate the challenges affecting the adoption of Industry 4.0 technologies in the Zimbabwean construction industry.

Design/Method/Approach
The study used a pragmatic philosophy, wherein a mixed approach was adopted. Questionnaires and interviews were used to collect data from construction professionals in Harare and Bulawayo, mainly because that is where the majority of construction companies in Zimbabwe are found. The was analysed using descriptive and inferential statistics (factor analysis).

Findings
The results of the study show that the five main challenges affecting Industry 4.0 technology adoption are Financial resources and profitability challenges, organizational challenges, managerial challenges, technical challenges, and Human resource challenges.

Practical Implications (if applicable)
The study results call for contractors to make strategic partnerships with high-tech companies, and for the Government of Zimbabwe to avail incentives or "innovation loans" to try and caution against investment costs associated with the adoption of IR 4.0 technologies.

Research Limitations (If applicable)
Given the small sample size, there is a need to exercise caution when generalising the results to other regions.

Keywords: Industry 4.0, challenges, construction industry, project delivery
1.0 INTRODUCTION

Modern construction urgently requires smarter resources, but smart construction is still a stub [62]. The consequences of using outdated technology in the Zimbabwean construction industry are time and cost overruns, poor health and safety practices, and low-quality administration, hence leading to unsuccessful and unsatisfactory project delivery [36]. The use of obsolete technology and limited use of digital information in the Zimbabwean construction industry is leading to unsuccessful construction project delivery in terms of low-quality administration, poor health and safety performances, and time and cost overruns [44]. More so, going digital is needful to transform the construction industry and increase its productivity [11]. Digitisation can, thus, greatly reduce lead times, costs, environmental impact, and carbon emissions, which are age-old challenges in the construction industry [41].

The transformation of organisations to this digital form, known as Industry 4.0 (I4.0), is the concept of the fourth industrial revolution [54]. When used in the construction industry, the word industry 4.0 is transformed into construction 4.0, which encompasses all technologies that facilitate digitisation and automation in the construction environment [61]. The technologies that the construction industry has adopted since the birth of Industry 4.0 include Internet of Things, simulation, autonomous systems, robotics, augmented reality, additive manufacturing, and big data. Construction 4.0 is not only conventional construction advanced with technological innovation; it is additionally a better approach to seeing and grasping construction in light of innovation and increase in productivity [22]. There are special applications that are only for construction, and these include Building Information Modelling (BIM), 3D construction printing, or modularisation of building components. Therefore, the construction sector has also adapted and not only applied the concept of Industry 4.0 in this field [64]. The adoption of such technologies, however, is faced with several challenges in the construction industry. Therefore, the objective of the study was to assess challenges affecting the adoption of I4.0 technologies in enhancing construction project delivery in Zimbabwe.

It is hoped that the study will benefit the construction industry by enlightening on the obtaining hindrances to IR 4.0 adoption, and also recommending viable solutions. The construction industry suffers heavily from an image problem resulting from several factors such as a harsh working environment and its low level of automation and digitisation. Since digitisation is known to significantly reduce lead time, costs, environmental impact, and carbon emission [41], enlightenment on its barriers and probable solutions can greatly benefit and better position construction stakeholders such as clients, architects, engineers, quantity surveyors, and contractors, just to name a few.

2.0 REVIEW OF RELATED LITERATURE

Challenges affecting Industry 4.0 adoption in the construction industry

The construction industry, which is vital to a country's GDP, has yet to figure out how to integrate Industry 4.0 advancements [45]. In comparison to manufacturing, the construction industry operates in a more sophisticated environment [6]. Transforming construction into a fully digital sector is challenging due to the industry’s fragmented character, site-based activity, and resistance to change [46]. Each structure is designed and constructed in accordance with specific criteria and stakeholder decisions, making Industry 4.0 more complex to implement than other industries [27]. In other words, the I4.0 drive in construction is still facing a lot of hurdles, and these include the high cost of implementation, cyber security breaches, lack of knowledge and training, and many more, which are summarised in Table 1.
The high cost of implementing technologies that eliminate manual labour is well-known in other industries, and its impact on adoption is obvious [24]. This same challenge is echoed by some scholars [2, 23, 10]. Implementation of IR4.0 technology leads to high technology ownership and operating costs, as most of the technology is not yet fully developed and is in the process of improvement or continuous development [23]. The same scholars point out that it is important to note that training costs for technical equipment can become expensive for owners, as such training may require external experts to train the workforce to be up-to-date in operation, which will increase valuable time and money.

When it comes to cyber security issues, security is a critical challenge in that information can be misused, and confidentiality can be breached [31, 22]. At the same time, quantifying cyberattacks is difficult to assess because most incidents go unreported to avoid reputational damage to the companies involved, or in some cases, companies never realise that such attacks have taken place, making these security breaches and cyberattacks far outweigh the benefits of digitisation and interconnectivity taking place in the construction industry [59]. More so, the increasing volume of data, the growing need for mobility, collaboration, and information sharing with external partners, leads to an increasing need for security and data protection [45]. Additionally, since the Industry 4.0 framework mandates the protection and security of the physical and cyber levels, inadequate security and assurance can act as a significant impediment to implementing Construction 4.0 [17]. While most large construction companies (both main contractors and subcontractors) have a cybersecurity policy in place, many smaller companies do not, hence the risk of cyber-attacks extends to different stages of the project [65].

Linked to cyber security issues is the challenge of limited IT resources and or infrastructure. The challenges that construction companies face as a result of adopting Industry 4.0 are not significantly different from those faced by other industries that have adopted new technologies and are at a high level of advanced digitisation [65]. However, some cyber risks are specific to the built environment, due to the number of stakeholders involved, the long supply chain, and the particularities of the different development phases of the construction project lifecycle. Exposure to cyberattacks in the construction industry is exacerbated by the number of stakeholders and the long supply chain, which mainly consists of SMEs with limited resources devoted to IT [65]. Similarly, [66] argues that the use of information and communication technology requires fast and reliable internet access on construction sites. Therefore, unreliable broadband connection or lack of access to high-speed connectivity for the mentioned collaboration applications is one of the biggest obstacles to overcome to fully adopt IR4.0 technologies in the construction industry. The rest of the challenges and associated scholars are summarised in Table 1.

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Sources</th>
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<tbody>
<tr>
<td>Scarcity of skilled labour</td>
<td>[20, 36, 51]</td>
</tr>
<tr>
<td>Need for development of new skills</td>
<td>[16, 18, 31]</td>
</tr>
<tr>
<td>Employee qualifications</td>
<td>[19, 27]</td>
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<tr>
<td>Resistance to change</td>
<td>[24, 27, 50, 58]</td>
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<tr>
<td>Lack of knowledge and training</td>
<td>[43, 50, 58]</td>
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<tr>
<td>Lack of managerial understanding and Poor decision making</td>
<td>[20, 38]</td>
</tr>
<tr>
<td>High costs of implementation</td>
<td>[2, 20, 21, 22, 24, 50, 58]</td>
</tr>
</tbody>
</table>
Unclear rate of return after investment \[38, 43, 50\]
High subscription and maintenance costs \[38, 63\]
Cyber-security breaches \[20, 24, 52\]
Inadequate cyber-security policies \[16, 59, 60\]
Limited IT resources \[20, 60, 62\]
Lack of government incentives \[18, 58\]

From the reviewed literature it can be concluded that several studies have been done on IR4.0 in the construction industry, and several challenges identified. The variability of the challenges amongst various studies, however, is evidence of the contextual significance. From a study done in the AEC areas \[20\] several factors hindering the adoption of robotics in construction were identified and these included workforce challenges, economic challenges, cultural challenges, industry-intrinsic challenges, and R&D challenges. Another study \[41\] furnished very useful information on Construction 4.0 organisational-level challenges and solutions. Several challenges were categorised into five main categories which are: human resources and society, organisational factors, management expectations, financial resources, and customer satisfaction. The study was qualitative where 29 interviewees were selected across the world. Most interviewees (selected experts), who were considered for the study based on their experience from their LinkedIn profiles, were however from the developed world. Some challenges were identified through systematic literature review studies \[39, 17, 22\]

In the developing world, \[63\] studied the challenges of implementing construction robotics technologies in Malaysia. Most of the challenges identified were, however, financial/cost-related. Another study \[58\] looked at barriers to the adoption of incorporating RFID with mobile technology for improved safety of construction professionals in South Africa. The study gleaned valuable and key barriers which include cost, low-tech ability, security of data, communication range, storage of data, additional weight of sensor on PPE, and power availability. More so, \[56\] looked at the driving forces and barriers of Industry 4.0. The study gave valuable insight into the barriers of Industry 4.0 by categorising them into five categories which were also ranked in order of criticality as follows: human resources, financial resources and profitability, management reality, organisational factors, and technological and process integration. The identified barriers were, however, generic to Industry 4.0 and not construction-specific, as intended by this study. Another study \[10\] looked at barriers to Industry 4.0 in the Zimbabwean construction industry but specifically addressed health and safety issues. This study broadens the scope by looking at I4.0 barriers to sustainable production, time and cost, and environmental impact. This was triggered by a study that pointed out that digitization can significantly reduce lead times, costs, environmental impact, and carbon emissions \[41\], which are age-old problems in the construction industry.

3.0 RESEARCH METHOD

A pragmatic research philosophy was used, as it is typically associated with mixed methods of research which enables the use of both qualitative and quantitative methods \[16\] and is descriptive. The study was carried out in Harare and Bulawayo, where, according to the CIFOZ list of 2022, 92% of the civil engineering and building companies are based. Also, according to the Zimbabwe Special Economic Zones Authority ZIMSEZA (2019), Bulawayo and Harare have the most construction companies and consultancy firms. The targeted population for this research consisted of quantity surveyors registered with the ZIQS, architects registered with ZIA, engineers registered with ZACE, and construction companies registered with CIFOZ categories A to C. The study used stratified sampling for construction companies registered with CIFOZ where categories from A to C were used as the strata, and thereafter simple random sampling to pick names of the different companies without replacement. A non-probability purposive sampling technique was used for key informants in the industry where interviews were conducted. On sampling, a sample size should be optimum \[29\], which is the one that fulfills the

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requirements of efficiency, representativeness, clarity, and validity. For this study 25% of the population in each category was sampled, giving a targeted sample size of 145 firms (29 contractors and 116 consultants).

Data collection: Semi-structured questionnaires and online interviews were used for primary data collection, while articles from peer-reviewed journals and textbooks were used for secondary data. Semi-structured questionnaires were emailed to respondents. The reliability of the data was ensured by the inclusion of four sections in the questionnaire. The first section ensured the collection of general information about the participants' academic qualifications, professions, and positions of respondents within the organizations. This data, when analysed, helped to strengthen the findings of the study. Likert-type scale was used in the study, where the respondents were asked to rank using a five-point Likert scale (5 =Very High, 4 = High, 3 = Neutral, 2 = Low, 1 = Very Low). An electronic questionnaire was used mainly because it was convenient for both the researcher and participants, fast, and it also eliminates the risk of transmitting Covid 19 and other related diseases. Both video and non-video call interviews were done with the aid of an interview guide, to key informants, considering their reputation and experience. One of the reasons for the use of interviews was to glean valuable information from key informants and also cross-validate the subject matter.

Data Analysis: Relative Importance Index (RII): RII is the proportionate contribution by each predictor, considering both the unique contribution of each predictor by itself and its incremental contribution when combined with other predictors. A 5-point Likert scale was used to come up with the Relative Importance Index (RII) which is calculated as RII = ΣW/AN where, RII =Relative Importance Index; W = Weighting given to each factor; A = the highest score (in this case, 5) and N = the total number of respondents

Factor Analysis: Factor analysis is best suited to deal with a large set of measured variables in a relatively small number of categories, referred to as factors. In addition, the technique allowed the researchers to group variables into factors so the inference can be considered as new variables, and their values are inferred by adding the values of the original variables grouped in the factor. SPSS was used to come up with eigenvalues and variances. The principal component analysis, with varimax rotation, was applied to extract components from the analysis, with those with eigenvalues >1 being significant and significant loadings from 0.5 upwards being considered as sufficient for use.

4.0 RESEARCH FINDINGS

4.1 Demographic profile of the respondents

Out of the targeted 145 online questionnaires 46 were completed, giving a response rate of 31.72%. This confirms that online surveys have a low response rate. More so, a related study was successfully done with 34 questionnaires. In addition, out of 11 targeted interviews with key informants, 8 were successfully conducted. The qualifications of the respondents were a diploma (7.41%), a Bachelor’s degree (51.85), a Master's degree (38.89), and a PhD (1.85%). This means more than 90% had at least a first degree.

4.2 Challenges affecting the adoption of IR 4.0 technologies in the Zimbabwean construction industry.

Respondents ranked on a scale of 1 to 5 the extent to which the listed challenges, gleaned from the literature, hinder full implementation of the IR4.0 technologies in the Zimbabwean construction industry. The data collected was then sorted and ranked using the Relative Importance Index (RII). The results that were obtained are presented in Table 2 below, where 1= Not at all, 2= Minor, 3= Moderate, 4= Near Major, and 5= Major.
From the results obtained, lack of knowledge & training (RII of 0.86), and costs of implementation (RII of 0.86) were the top-ranked challenges. These results are in line with a recent study [47], which indicates that the absence of knowledge and training results in a hazy understanding of the benefits of technologies and the economic and social value of development. Moreover, [2] points out that the high cost of technical equipment, training, and education, and external consulting fees are barriers to adoption. In addition, the implementation of IR4.0 technologies leads to high technology training and implementation costs and the long supply chain, which mainly consists of SMEs with limited resources devoted to IT [66].

Limited IT resources was the third-ranked (RII of 0.82) challenge. In other words, unreliable broadband connection or lack of access to high-speed connectivity for the mentioned collaboration applications is one of the biggest obstacles to overcome to fully adopt IR4.0 technologies in the construction industry. These results corroborate [66], that the use of information and communication technology requires fast and reliable internet access on construction sites. The exposure to cyberattacks in the construction industry is amplified by the number of stakeholders and the long supply chain, which mainly consists of SMEs with limited resources devoted to IT [65].

Cyber security breaches gave a significant hindrance of 0.72 RII and are the second lowest RII on the results obtained. In as much as this challenge is second lowest in ranking, its RII is high, implying it also has a significant effect. In support of this [59] points to its significance in hindering I4.0 adoption, highlighting that quantifying cyberattacks is difficult to assess because most incidents go unreported to avoid reputational damage to the companies involved. In some cases, companies never realize that such attacks have taken place making these security breaches and cyberattacks far outweigh the benefits of digitization and interconnectivity taking place in the construction industry, which discourages the adoption of Industry 4.0 in construction.

The scarcity of skilled labour has the lowest RII of 0.60. Although this was the lowest score, its RII is
also considerably high. It could be argued that this challenge is comparatively not critical, but on the other hand, the high RII could be attributed to brain drain which is quite high in the country, and specifically, in construction. In this regard, [13] claims that it is critical to comprehend and model the role of humans in designing future manufacturing systems that are efficient. According to their argument, successfully implementing Construction 4.0 requires looking beyond technology to identify hurdles to change. One such impediment is the scarcity of skilled labour, especially in developing nations [39].

In compliance with the literature of different scholars reviewed in this study, 13 challenges were considered important, considering the 0.60 and above RII obtained. These survey results show that the identified challenges have a huge impact on hindering the IR4.0 implementation in the Zimbabwean construction industry.

**Factor Analysis**

Factor analysis was used to simplify the relationships that exist among the challenges. The principal component analysis and varimax rotation were incorporated for factor extraction with Kaiser Normalization, as shown in Table 3. Five components of challenges were extracted from the analysis with an Eigenvalue of greater than 1, which explained 73.6% of the total variance with factor loadings ranging from 0.914 to 0.585. The five components are discussed below.

**Table 3** Challenges affecting adoption of IR 4.0 technologies in Zimbabwean construction industry.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Challenges</th>
<th>Component (Rank)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Cost-related Challenges</strong></td>
<td></td>
<td>0.732</td>
<td>0.834</td>
<td>0.859</td>
<td>0.781</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High costs of implementation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unclear rate of return after investing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High subscription costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High maintenance costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>Digital skills and Literacy Challenges</strong></td>
<td></td>
<td>0.768</td>
<td>0.649</td>
<td>0.692</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need for development of new skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance to change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of knowledge and training</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Managerial Challenges</strong></td>
<td></td>
<td>0.914</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of managerial understanding</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor decision making within management</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>Technical Challenges</strong></td>
<td></td>
<td>0.585</td>
<td>0.864</td>
<td>0.598</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cyber-security breaches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate cyber-security policies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited IT resources</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Human Resources Challenges</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
Component 1 Cost-related Challenges. The first component was named “Cost-related challenges” and accounts for 3.846 Eigenvalue and a variance of 29.586%. The challenges incorporated in this component were High cost of implementation (sig. = 0.732), Unclear rate of return after investment (sig. = 0.834), High subscription costs (sig. = 0.859), and High maintenance costs (sig. = 0.781). This component was mostly constituted of financial-related challenges as the most significant. This implies that the financial position of most stakeholders or companies in Zimbabwe is a key ingredient to the rate of adoption of I4.0. The same was highlighted by Interviewee 3:

"We cannot afford it. In as much as we want to use licensed soft wares which you are forced to renew every year because they are upgraded yearly (a particular reference to BIM) we just cannot afford"

Interviewee 2 raised the same concern:
"Cost is another problem. There is the issue of the initial investment, hardware, soft wares, and the licensing itself".

So from the Zimbabwean perspective, financial resources and profitability are critical challenges maybe because of the current economic hardships. More so, high subscription costs were the most significant challenge in the group and its importance is supported by [57] who highlights that certain technologies have a high subscription cost, which results in stakeholders being left out. The cost of acquiring and subscribing to robotics software, for example, must decrease significantly for it to spread throughout the business [41].

Component 2 Digital skills and literacy challenges. The second component was named “Digital skills and literacy challenges,” and accounts for 1.787 Eigenvalue and a variance of 13.745%. The challenges included in this component are: Need for the development of new skills (sig. = 0.768), Resistance to change (sig. = 0.649), and Lack of knowledge and training (sig. = 0.692). According to [20] social and mental changes are crucial to preparing workers for the future human-robot collaboration that will bring new occupations and responsibilities to the construction industry on a daily basis. The same was also raised by another interviewee:

"Lack of knowledge is a key challenge. Most industry players, especially the old folks are not willing to embrace these technologies because they don’t know the benefits of doing that. They want to stick to their old approaches and techniques"

More so, this view is in line with the results in the same table (3), where resistance to change, which has a sig. of 0.649, is echoed [26] as the most powerful barrier to change, which if not properly handled, can significantly impede successful introduction of new technology, maybe stemming from employees who are afraid to lose their jobs.

Component 3 Managerial Challenges. The third component was named "Managerial challenges," and accounts for 1.566 Eigenvalue and a variance of 12.049%. The challenges included in this component are: Lack of managerial understanding (sig. = 0.914), and Poor decision-making within management (sig. = 0.790). From the results, Lack of managerial understanding was the most significant challenge in the group, implying they are
unaware of the advances and techniques, which then in turn placed them under intense strain [41]. Therefore, with the lack of managerial understanding, decision-making becomes very challenging, especially with the absence of information about technology speculations.

Component 4 Technical Challenges. The fourth component was named "Technical challenges" and accounts for 1.279 Eigenvalues and a variance of 9.838%. The challenges included in this component are: Cyber-security breaches (sig. = 0.585), Inadequate cyber-security policies (sig. = 0.864), and Limited IT resources (sig. = 0.598). From this component group, inadequate cyber-security policies were the most significant challenge in the group. These findings are in sync with [59] who argue that cyber-attacks far outweigh the benefits of digitisation and interconnectivity taking place in the construction industry. Additionally, [17] argues that since the Industry 4.0 framework mandates the protection and security of the physical and cyber levels, inadequate security and assurance can act as a significant impediment to implementing Construction 4.0.

Component 5 Human Resources Challenges. The fifth component was named "Human Resources challenges" and accounts for 1.088 Eigenvalues and a variance of 8.366%. The component has one challenge, which is the scarcity of skilled labour (sig. = 0.858). Skills shortage is an ongoing problem in developing countries due to unsustainable wages and working conditions, which results in a massive brain drain. However, to successfully implement IR 4.0 technologies requires good experience and trained professionals and construction workers. While the construction industry has historically struggled with a lack of labour and human resources, the COVID-19 epidemic added to the industry's mental health and burnout concerns [22].

5.0 CONCLUSIONS AND RECOMMENDATIONS

The study investigated the challenges affecting the adoption of Industry 4.0 technologies to enhance project delivery in Zimbabwe. The results of the descriptive analysis show that 13 factors affect the adoption of Industry 4.0 technologies. The top five factors are: high cost of implementation; lack of knowledge and training; limited resources; employee qualifications; and high subscription costs. In addition, Factor analysis revealed 5 main factors, namely: cost-related challenges; digital skills and literacy; managerial challenges; technical challenges; and human resources challenges. The results highlight the need for construction companies to engage in more information dissemination programs like the building expo to help disseminate the information, especially regarding the adoption of IR 4.0 technologies, their possible benefits, and clarity of the long-term cost of these technologies. The study further highlights the need for digital skills among construction practitioners. This calls for built environment training institutions to integrate Industry 4.0 technologies in their training and the need for continuous professional development courses to reskill and upskill practitioners relative to Industry 4.0. This could speed up the rate of shifting from the traditional methods to the modern building methods which enhances successful project delivery. It is a fact there is a high initial cost of implementing IR 4.0 which has been accumulated to be a barrier. In addition, the results impress on the need for the Government to avail "innovation loans and subsidies" to cushion construction firms to economically implement IR 4.0. These can be issued through the available building societies and/or a new institution created for this purpose. Companies should conduct regular training and awareness campaigns for their employees to encourage adopting these technologies through constant reminders of the importance and benefits associated with the adoption of IR 4.0. Stakeholders should seek to source adequate funds with flexible payment methods to be able to afford these technologies. Given the small sample size, there is a need to exercise caution when generalising the results to other regions.

6.0 REFERENCES


ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa


Recent Trends of Geopolymer Development in the Southern African Built Environment

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ABSTRACT

Purpose
In compliance with the COP21 Paris Agreement of addressing global climate change by 2050, the reuse of waste materials for geopolymer development has tremendously grown worldwide but little is known about the trend of geopolymer development in the Southern African built environment. Geopolymer is pioneered as a sustainable green construction material and third-generation binder. The present study aims to examine the current trend in geopolymer development in the Southern African region from 2013 to 2023 which is prone to rapid urbanization, housing challenges, and an influx of industrial waste in landfills.

Design/methodology/approach
To achieve the objective of the present study, a bibliometric analysis based on bibliographic data retrieved from Scopus was used to identify the geopolymer development trends and projections for future research in Southern Africa. VOSviewer software was used for network visualization of the bibliographic data.

Findings
The findings indicate that Construction and Building Materials, Materials, and the Journal of Cleaner Production are the top publication journals. However, the Journal of Environmental Management has the top citation number. Geopolymers and Inorganic polymers are the most occurring keywords. At a global scale, geopolymer research in the Southern African region is still in its infancy as it contributes less than 1\% of global geopolymer publications implying the need for greater support, funding, curricula, policies, and continued research to sustain the new binder development for the built environment.

Research limitations/implications
Only the Scopus database was used for retrieving bibliographic data written in English thus excluding data written.
in other languages. Therefore, further studies can be done using different databases, languages, and network mapping software.

**Originality/value of paper**

This paper delineates the geopolymer knowledge domain and identifies future research areas for the sustainability of the built environment in Southern Africa. Furthermore, this paper fosters up-to-date innovative collaboration in geopolymer research and reduction of environmental impact through the reuse of industrial waste materials in line with the circular economy and sustainable development goals (SDGs) 9, 11, 12, and 13. Emerging researchers in the geopolymer field will be guided by the output of the present study to focus on trending research areas that will further facilitate the adoption of geopolymers in Southern Africa’s built environment for sustainable infrastructural development.

**Keywords:** Alternative cement, circular economy, geopolymer, sustainability, waste recycling
1.0. Introduction

The manufacture of ordinary Portland cement (OPC) currently at an output of 4 billion tons per year contributes about 8% (2.8 gigatons/y) to global greenhouse gas emissions and is projected to grow due to an increase in infrastructural development worldwide (Chindaprasiit & Rattanasak, 2023; Ellis et al., 2020). The production of 1 ton of OPC consumes about 2 tons of natural raw materials and emits 1 ton of CO2 (Almutairi et al., 2021). The average fuel energy consumed to produce 1 ton of OPC ranges from 3.6 GJ/t to 6 GJ/t depending on the kiln type, fuel source, and location (Alsalman et al., 2021). Researchers are working on developing various alternative cementitious materials to OPC to address global greenhouse gas emissions through the reuse of industrial waste materials in conformity with the circular economy and SDGs 9, 11, 12, and 13. Disposing of industrial waste and/or by-products in landfills is hazardous to the ecosystem and hence the reuse of the waste materials to produce construction materials offers a sustainable route to conform to circularity (Nodehi & Taghvaei, 2022). Geopolymer has been pioneered as a sustainable third-generation binder alternative to OPC as it has comparable physicomechanical properties (Matsimbe et al., 2022b), low CO2 emission (McLellan et al., 2011; Mellado et al., 2014), and reduced embodied energy (Turner & Collins, 2013). The terminology of geopolymer was invented by Professor Joseph Davidovits in 1978 (Davidovits, 1991, 2020) to refer to inorganic polymeric materials deduced from the chemical reaction between aluminosilicate precursors and alkali hydroxide and/or silicate forming poly(sialate) bonds (Matsimbe et al., 2023). The skyrocketing population growth and industrialization have increased the disposal of waste materials e.g., palm oil fuel ash, red mud, fly ash, granulated blast furnace slag, rice husk ash, phosphogypsum, etc., in landfills which creates an environmental hazard. The manufacture of geopolymers requires high aluminosilicate precursor materials, which can be sustained by reusing the abundant readily available industrial waste materials, hence providing a circularity route, and minimizing environmental pollution (Ahmed et al., 2023; Hassan et al., 2020; Shehata et al., 2022).

Geopolymeric products are widely applied in the development of infrastructure (Ayub & Khan, 2023; Matsimbe et al., 2023; Tian et al., 2022; Yang et al., 2022; Zakka et al., 2021). In the long-term, geopolymer offers an eco-friendly sustainable route to supplement/replace OPC and effectively manage solid waste disposal. However, there is no available literature that has bibliometrically examined the geopolymer research trends in Southern Africa. This knowledge gap can derail the advancement of geopolymer research in Southern Africa. The development trend of geopolymers in Southern Africa’s built environment is unknown and therefore the research gap to be addressed is whether Southern Africa has the capacity and support to develop and incorporate geopolymers in its built environment. The present study aims to examine the current trend in geopolymer development from 2013 to 2023 in Southern Africa identified as a region prone to rapid urbanization, housing challenges, and an influx of industrial waste in landfills. The significance of the present study to literature comprises delineating the geopolymer knowledge domain and identifying future geopolymer research areas to promote innovative research collaboration to benefit the built environment in Southern Africa. Furthermore, this study fosters the advancement of geopolymer adoption, the reduction in consumption of Portland cement which contributes significantly to CO2 emissions, and the reduction of environmental impact through the reuse of industrial waste materials in line with circularity and SDGs 9, 11, 12, and 13. Emerging researchers in the geopolymer field will be guided by the output of the present study to focus on trending research topics that will facilitate the adoption of geopolymers in Southern Africa’s built environment for sustainable infrastructural development.

2.0. Literature review

Geopolymers are products from the synthesis of aluminosilicate precursors with alkali hydroxides, silicates, and/or acidic mediums (Alkadhim et al., 2022). The aluminosilicate materials can either be natural e.g.,
laterite, metakaolin, and volcanic ash, or industrial by-products/waste materials e.g., fly ash, granulated blast furnace slag, rice husk ash, phosphogypsum, and mine tailings (Ahmed et al., 2023; Cong & Cheng, 2021; Tchadjie & Ekolu, 2018). Figure 1 illustrates the complete geopolymer production process from selecting an aluminosilicate precursor, mixing the precursor with an activator, curing the mixture, and up to the final geopolymer product e.g., paste, mortar, and concrete. The chemical compounds formed usually have repeating units such as silico-oxide (-Si-O-Si-O-), silico-aluminate (-Si-O-Al-O-), ferro-silico-aluminate (-Fe-O-Si-O-Al-O-), or aluminophosphate (-Al-O-P-O-) formed from the geopolymerization process (Davidovits, 2020). Geopolymer products are being used in buildings, airports, and 3D printing (Geopolymer International, 2023; Glasby et al., 2015; Renca, 2023). The physicomechanical properties of the geopolymers are influenced by the alkaline activator concentrations, curing conditions, and precursor (Singh et al., 2023). The foregoing shows that selecting waste materials high in alumina and silica is crucial to the successful development of geopolymers. The commonly used aluminosilicate waste material is fly ash since it is abundantly available and has favourable chemical properties to ensure a robust product. The mechanical properties of the fly ash-based geopolymers are enhanced by adding admixtures (Jindal, 2019) and producing binary mixtures (Hu et al., 2021).

Figure 1. An illustration of the geopolymer production process (Matsimbe et al., 2022b)

3.0. Methodology

To achieve the objective of the present study, a bibliometric analysis based on bibliographic data retrieved from Scopus (period 2013 to 2023) was used to identify the geopolymer development trends and projections for future research in Southern Africa. A similar methodological technique was used by Matsimbe et al., 2023; Tian et al., 2022; and Yang et al., 2022. VOSviewer software was used for network visualization of the bibliographic data. The commonly used scientific databases are Scopus, Google Scholar, and Web of Science (Li et al., 2021). The present study used the Scopus database for data retrieval and article selection due to its large academic citation and abstract database (Nobre & Tavares, 2017; Verrall & Pickering, 2020) and coverage of a wide subject range comprehensively (Adedayo et al., 2021; Agbodjan et al., 2022; Mongeon & Paul-Hus, 2016). VOSviewer version 1.6.19 open-source software (van Eck & Waltman, 2010) was applied for bibliometric network visualization and mapping development trends focusing on keyword co-occurrence, yearly publications,
leading authors, top-cited publications, publication sources, and countries. VOSviewer provides a unique speedy illustration of graphics and bibliometric maps (Zakka et al., 2021). Table 1 shows the inclusion principle of data retrieved in Scopus. The abstracts of the retrieved articles were checked to ascertain their pertinence and to filter out any duplicates. The data was then exported in CSV format to VOSviewer version 1.6.19 for bibliometric network visualization.

<table>
<thead>
<tr>
<th>Option</th>
<th>Inclusion Criteria</th>
</tr>
</thead>
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<td>Language</td>
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</tr>
<tr>
<td>Publication date</td>
<td>2013–2023</td>
</tr>
<tr>
<td>Subject area</td>
<td>Engineering, Material Science, Environmental Science</td>
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<tr>
<td>Source type</td>
<td>Journal</td>
</tr>
<tr>
<td>Document type</td>
<td>Article, Review, Conference Paper</td>
</tr>
<tr>
<td>Country/Territory</td>
<td>Southern Africa</td>
</tr>
</tbody>
</table>

4.0. Results and Discussion

4.1 Yearly publications

Figure 2 (a) shows the annual geopolymer or alkali-activated materials publication from 2013 to 2023. However, there were no publications from 2013 to 2014 which can be attributed to limited interest at that time since the SDGs had not been adopted yet by the United Nations General Assembly. After the adoption of the SDGs in 2015, geopolymer research in Southern Africa has steadily grown from 3 publications in 2015 to 20 publications in 2023. Cumulatively, the publication trend increased from 3 in 2015 to 83 in 2023. Furthermore, the decrease in publications in 2021 could be attributed to the effects of COVID-19 which affected the delivery of teaching and research in universities and industry. Fig. 2 (b) shows an exponential growth with a coefficient of determination ($R^2$) of 0.8682 implying a positive trend in the research field. Instead of continuously depleting the virgin materials to produce Portland cement, it is worthwhile to recycle industrial waste materials for geopolymer development which is a clinker-free low CO2 binder with comparable mechanical properties to OPC. Comparatively to the global scale (Matsimbe et al., 2022a, 2023; Zakka et al., 2021), geopolymer research in Southern Africa is still emerging as it contributes less than 1% of global publications implying the need for greater support, funding, updated curricula, policies, and continued research to sustain the development of the new binder for use in the built environment. The promotion of the circular economy at the local and global scale requires all countries to address industrial waste by reusing and/or recycling it into eco-friendly economical products for construction. This can help address the housing challenges faced by many people in Southern Africa. Also, having an alternative binder to OPC will help stabilize cement prices on the market due to competition instead of monopoly. The production of eco-friendly low-cost construction materials is important to the development of the built environment in Africa (Mhlanga et al., 2022; UN-Habitat, 2011).
4.2 Publication sources

Table 2 shows that Construction and Building Materials (n=12), Materials (n=7), and Journal of Cleaner Production (n=5) are the top geopolymer publication sources in Southern Africa. However, in terms of citations, the Journal of Environmental Management has more citations (n=292) succeeded by Construction and Building Materials (n=228), Journal of Cleaner Production (n=109), and Materials (n=52).

<table>
<thead>
<tr>
<th>S/N</th>
<th>Source</th>
<th>Number of Publications</th>
<th>Total Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction and Building Materials</td>
<td>12</td>
<td>228</td>
</tr>
<tr>
<td>2</td>
<td>Materials</td>
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<td>3</td>
<td>Journal of Cleaner Production</td>
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<td>109</td>
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<td>4</td>
<td>Journal of Environmental Management</td>
<td>4</td>
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<tr>
<td>5</td>
<td>Advances in Civil Engineering</td>
<td>3</td>
<td>20</td>
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<tr>
<td>6</td>
<td>Materials Today: Proceedings</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>7</td>
<td>Journal of Solid Waste Technology and Management</td>
<td>3</td>
<td>22</td>
</tr>
</tbody>
</table>

Figure 3 shows that there are four groups of journals interlinked in citation i.e., yellow, blue, red, and green clusters. The circle size shows the number of documents published, i.e., a larger size implies many publications by the journal. The bigger size of the Construction and Building Materials journal shows its relevance in publishing geopolymer studies. This concurs with Matsimbe et al., 2023 and Zakka et al., 2021 who observed that the Construction and Building Materials journal has a greater impact and prestige in disseminating geopolymer research.
4.3 Keyword co-occurrence

Keyword co-occurrence portrays the trending domain areas in a research field (Matsimbe et al., 2023). Table 3 shows that the common keywords are Geopolymers (n=52), Inorganic polymers (n=47), and Compressive strength (n=40). The interest is to develop a cementitious material (i.e., geopolymer) that is well understood in terms of its physical, chemical, and microstructural properties for better mechanical performance (i.e., compressive strength) comparable to how OPC has been studied from 1824 to the present (almost 200 years) thereby instilling confidence in its usage.

Table 3: Commonly used keywords

<table>
<thead>
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<th>S/N</th>
<th>Keyword</th>
<th>Occurrence</th>
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<tr>
<td>1</td>
<td>Geopolymers</td>
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<tr>
<td>2</td>
<td>Inorganic polymers</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>Compressive strength</td>
<td>40</td>
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<td>4</td>
<td>Fly ash</td>
<td>38</td>
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<tr>
<td>5</td>
<td>Sodium hydroxide</td>
<td>33</td>
</tr>
<tr>
<td>6</td>
<td>Silicates</td>
<td>21</td>
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<tr>
<td>7</td>
<td>Slags</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td>Curing</td>
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</tbody>
</table>

Figure 3: Network showing publication sources

Figure 4 shows that there are two groups visualized in the network map, i.e., green cluster and red cluster. The larger-sized circles imply trending keywords compared to the smaller-sized circles. This concurs with Alkadhim et al., 2022 and Matsimbe et al., 2022a who showed that geopolymers and inorganic polymers are highly used keywords. Sodium hydroxide is a commonly preferred alkali activator as it promotes better dissolution of the aluminosilicate giving an improved geopolymerization matrix and greater compressive strength compared to potassium hydroxide (Abdul Rahim et al., 2014; Ahmed et al., 2021; Sai Ketana et al., 2021; Sithole & Mashifana, 2020). Fly ash and slags are the most used aluminosilicate precursors due to their abundant availability locally and globally which also agrees with studies by (Falayi, 2019; Matsimbe et al., 2022b; Sithole & Mashifana, 2020; Zhou et al., 2023). Most of the fly ash in South Africa is produced from about 15 coal-fired power plants majorly located in the Mpumalanga province. The annual production of fly ash in South Africa is around 40 million tonnes (Matsimbe et al., 2022b).
Jabulani Matsimbe, Megersa Dinka, David Olukanni and Innocent Musonda et al., (2022b), phosphogypsum at 35 million tonnes (Matsimbe et al., 2022b), gold mine tailings at 600 000 tonnes (Falayi, 2020), blast furnace slag about 3 million tonnes (Kambole et al., 2019), waste glass at 300 000 tonnes (Luhar et al., 2019), which might explain why most of the leading authors in the Southern Africa region are from South Africa. The continued increase of these industrial wastes requires additional land for disposal which pollutes the environment hence the need to recycle and reuse for cementitious materials production e.g., geopolymers, thereby addressing circularity and SDGs 9, 11, 12, and 13.

Figure 4: Network of keyword co-occurrence

4.4 Leading authors

Table 4 shows key authors contributing to geopolymer literature. Stephen Ekolu affiliated with Nelson Mandela University has the highest number of publications (n=11) followed by Thandiwe Sithole (n=10) from the University of Johannesburg, and Abdolhossen Naghizadeh (n=9) from the University of Free State. In terms of the total number of citations, the top authors are Stephen Ekolu (n=222), Julia Shekhovtsova (n=132), Leonel Tchadjie (n=111), and Abdolhossen Naghizadeh (n=100). The development and implementation of any invention and/or technology requires human expertise in that specific field otherwise it would be in vain. Therefore, an increase in geopolymer expertise and researchers in Southern Africa will help advance the theory and practice of geopolymers to meet industrial demands and advance the circular economy and/or sustainable development goals.
Table 4. Key authors based on publication and citation.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Author</th>
<th>Affiliation</th>
<th>Publications</th>
<th>Total Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stephen Ekolu</td>
<td>Nelson Mandela University</td>
<td>11</td>
<td>222</td>
</tr>
<tr>
<td>2</td>
<td>Thandiwe Sithole</td>
<td>University of Johannesburg</td>
<td>10</td>
<td>87</td>
</tr>
<tr>
<td>3</td>
<td>Abdolhossen Naghizadeh</td>
<td>University of the Free State</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Thabo Falayi</td>
<td>Namibia University of Science and Technology</td>
<td>7</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>Ntuli Freeman</td>
<td>Botswana International University of Science and Technology</td>
<td>6</td>
<td>52</td>
</tr>
<tr>
<td>6</td>
<td>Julia Shekhovtsova</td>
<td>University of Pretoria</td>
<td>5</td>
<td>132</td>
</tr>
<tr>
<td>7</td>
<td>Tebogo Mashifana</td>
<td>University of Johannesburg</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>8</td>
<td>Felix Okonta</td>
<td>University of Johannesburg</td>
<td>4</td>
<td>52</td>
</tr>
<tr>
<td>9</td>
<td>Leonel Tchadjie</td>
<td>University of Johannesburg</td>
<td>4</td>
<td>111</td>
</tr>
<tr>
<td>10</td>
<td>Innocent Musonda</td>
<td>University of Johannesburg</td>
<td>4</td>
<td>32</td>
</tr>
</tbody>
</table>

4.5 The most cited publications

Table 5 shows the publications which have been highly cited. This implies that these publications are of significance to most researchers and contain information that influences the field. The article with the most citations is “Enhancing the reactivity of aluminosilicate materials toward geopolymer synthesis” with 92 citations succeeded by “Estimation of fly ash reactivity for use in alkali-activated cements - A step towards sustainable building material and waste utilization” with 51 citations. As can be observed, the key aspect is ‘reactivity’ which greatly affects the mechanical properties of the geopolymer. Hence, the understanding of the reactivity of the different aluminosilicate precursor materials (Gong & White, 2023) and/or industrial waste materials will advance knowledge on material selection, classification, and improvement of the final geopolymer product. Researchers have also considered the use of natural fibers to enhance the structural integrity of geopolymer concrete dependent on the fiber type, length, and volume concentration (Abdalla et al., 2023).
Table 5: The most cited publications

<table>
<thead>
<tr>
<th>S/N</th>
<th>Publication</th>
<th>Total citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Enhancing the reactivity of aluminosilicate materials toward geopolymer synthesis (Tchadjie &amp; Ekolu, 2018)</td>
<td>92</td>
</tr>
<tr>
<td>2</td>
<td>Estimation of fly ash reactivity for use in alkali-activated cements - A step towards sustainable building material and waste utilization (Shekhovtsova et al., 2018)</td>
<td>51</td>
</tr>
<tr>
<td>3</td>
<td>Method for comprehensive mix design of fly ash geopolymer mortars (Naghizadeh &amp; Ekolu, 2019)</td>
<td>44</td>
</tr>
<tr>
<td>4</td>
<td>A comparison between fly ash- and basic oxygen furnace slag-modified gold mine tailings geopolymers (Falayi, 2020)</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Geosynthesis of building and construction materials through alkaline activation of granulated blast furnace slag (Sithole &amp; Mashifana, 2020)</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>Incorporation of activated bauxite to enhance engineering properties and microstructure of volcanic ash geopolymer mortar composites (Tchadjié et al., 2021)</td>
<td>19</td>
</tr>
</tbody>
</table>

5.0. Future Research Trends
The promotion of geopolymers as a novel binder technology requires further research to reach the level of OPC invented 200 years ago. Therefore, the present study identified the following key areas to advance the adoption of geopolymers in the built environment locally and globally:

- Formulation of universal mix designs and design standards.
- Development of a powdered activator.
- Development of strength predictive models.
- Improvement of room temperature curing.
- Understanding the reaction processes, engineering properties, and durability of unary, binary, or ternary geopolymer products.
- Application of reinforcement in structural geopolymer members.
- Development of cost estimates and pilot plants.

6.0. Limitations
Only the Scopus database was used for retrieving bibliographic data written in English thus excluding data written in other languages. Therefore, further studies can be done using alternative databases, languages, and visualization software.
7.0. Conclusions
The present study examined the recent trends in the development of geopolymers to promote innovative research collaboration in the Southern African built environment which is geared to grow its innovative and scientific landscape as alluded to by the Department of Science and Innovation, 2022. The research on geopolymer has grown exponentially worldwide hence the need for Southern Africa to be equipped with the necessary technical capacity and collaborative knowledge to join the global race in combating greenhouse gas emissions, rapid urbanization, housing challenges, and an influx of industrial waste in landfills thereby addressing circularity and sustainable development goals 9, 11, 12, and 13. The Organisation for Economic Cooperation and Development OECD, 2022 advocates for the coordination and collaboration of research activities for the mutual growth of the global knowledge base. The bibliometric network visualization backed up with literature analysis provides a scientific basis for emerging and existing researchers to further expand the theory and application of geopolymers for sustainable infrastructural development in Southern Africa in tandem with global trends on circular economy. The leading journals publishing geopolymer research in Southern Africa are Construction and Building Materials, Materials, Journal of Cleaner Production, and the Journal of Environmental Management. The commonly used keywords are Geopolymers, Inorganic polymers, and Compressive strength. Due to limited long-term geopolymer durability studies compared to OPC which has been studied for 200 years, there is still a need for continued geopolymer research, and pilot plant studies to ensure total adoption by the built environment in Southern Africa. This study fosters the advancement of geopolymer adoption, the reduction in consumption of Portland cement which contributes significantly to CO₂ emissions, and the reduction of environmental impact through the reuse of industrial waste materials in line with circularity and SDGs 9, 11, 12, and 13.

8.0. Acknowledgements
This research is funded by the Intra-Africa Mobility Scheme of the European Union in partnership with the African Union in the framework of the project 624204-PANAF-1-2020-1-ZA-PANAF-MOBAF under the Africa Sustainable Infrastructure Mobility (ASIM) scheme. Opinions and conclusions are those of the authors and are not necessarily attributable to ASIM. The work is part of collaborative research at the Centre of Applied Research and Innovation in the Built Environment (CARINBE).

9.0. Conflicts of Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

10.0. References

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ASOCESA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
Jabulani Matsimbe, Megersa Dinka, David Olukanni and Innocent Musonda


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https://doi.org/10.1007/s11783-023-1750-9
Productivity Enhancement and Developing Framework for Road Maintenance: A Case Study of Two Metropolitan Municipalities

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ABSTRACT

Purpose of this paper

The study aims is to increase productivity and develop a maintenance framework for the road infrastructure within the two metropolitan municipalities (eThekwini Metropolitan Municipality and City of Johannesburg Roads Agency). The objectives of the research are:

a) Determine the effective way of utilising municipal internal capacity in roads maintenance.
b) Determine the best utilisation of road equipment and material within the roads maintenance to increase productivity.
c) Analysing and recommending the time it should take road maintenance teams to attend to road infrastructure defects.
d) Recommending training and areas of development for municipal maintenance teams.

Methodology

Method utilised in the research is qualitative, with several interviews to be conducted and an on-site motion study survey. The first step was an extensive literature review to provide a thorough understanding of productivity improvement in municipal road maintenance. An interpretative approach to knowledge was adopted in the second phase of the research. In phase three, to guarantee validity and reliability, participants will be asked to complete a structured questionnaire.

Findings

Road repair and resurfacing are underfunded; (b) Some depot managers lack the necessary qualifications; (c) Service requests take longer to process; and (d) High vacancy rate.

Research limitations

The non-availability of municipal staff to be interviewed; b) The challenge in accessing data to be analysed; and c) The study might be regarded as invasive by the two Metropolitans.
Practical implications: Outcomes and implications for practice will be the reduction of outsourcing for road maintenance services and the provision of relevant training and development of internal municipal staff members.

Value of paper
There will be a development of a road maintenance framework for the municipalities that will assist municipalities to a) properly schedule maintenance, b) measure processes and areas affecting production, and c) implement cost-effective maintenance.

Keywords: capacity improvement, roads maintenance framework, roads maintenance standards, productivity improvement.
1. Introduction

According to MDB (2017), South Africa comprise eight category-A metropolitan municipalities. The City of Johannesburg Municipality and The City of eThekwini Municipality are part of the eight category-A metropolitan municipalities. According to Stats SA (2016), 33.7% of all people in South Africa live in these metropolitan municipalities. Governance is facilitated by a variety of key infrastructures, including the road infrastructure network. The primary supporting infrastructure for how residents travel between locations using various means of transportation is the roads network. Planning, designing and enhancing the system of movement in the city’s streets, sidewalks and road intersections, including the traffic signal control system, for optimal security and efficiency is part of the municipality’s fundamental responsibility with regard to road infrastructure.

In order to strike a balance between maintaining and renewing current infrastructure while simultaneously resolving infrastructure backlogs, municipalities’ limited resources must be directed towards the most urgent demands (DPLG, 2006). To extend the lifespan of the infrastructure and delays reconstruction, municipalities must maintain their road systems properly. Adequate upkeep enables the government to allocate significantly less financial resources on infrastructure repair. If a project has a design life of a decade but receives no maintenance, it will need to be completely rebuilt in year seven. (McCutcheon & Marshal, 1998). It will be challenging to assess the effectiveness of internal teams in municipalities responsible for maintenance if performance is not documented and assessed.

The performance targets should be measured in terms of response time in order to evaluate operational development and the effectiveness of the maintenance teams (GTAC, 2015). The CoJ is the only metro that evaluates reaction time, according to a review of the metros’ goals for success for its roads network. However, most governments do not consistently utilise the information from asset management systems in their decision-making, which results in significant wastage of time and resources used for infrastructure maintenance (Daniela, 2011).

According to GTAC (2016), there was no scientific study conducted by JRA or CoJ when generating KPIs for road maintenance. Realistic goals must be attained in order to monitor municipal services (Pretorius & Schurink, 2007). Additionally, there is no evidence that a study done on the operational teams of the JRA’s capacity to respond to service requests as specified in the JRA Service Level Agreement.

2. Review of the Operational Improvement and Productivity Literature

Various studies have been undertaken on operational improvement within the South African context and the continent. These studies focused more on improving performance and efficiency in the workplace and the challenges involved in improving productivity. However, no evidence has been of a study focussing on improving productivity and efficiency within the maintenance municipal environment. In the South African public service, the most current case study relating to operational improvement was commissioned in 2015 by the Department of Home Affairs (DHA). In this literature review, it was essential to commence by seeking understanding of the most important concepts in this study. The discussion below explains concepts of operational improvement and improving productivity to ensure a breakthrough in the implementation and monitoring processes.

2.1 Definitions that relate to operational improvement Productivity

Allal and Edmonds (1977) define productivity as evaluating and subdividing time spent on the operation.
Bain (1982) defines productivity as the ratio of some output to some input. Bain (1982) defines productivity as a measure of how effectively resources are integrated and utilised to achieve particular and desired objectives rather than a measure of production or output created.

### 2.2 Improving Productivity and Effectiveness (Mundel, 1983)

The objectives

The aim was to facilitate the measurement and improvement of the effectiveness and productivity in organisations. The study covered a wide range of case studies showing the application of the methodology in several companies, included printing, shipbuilding, hospitals, and banking, to mention a few. Mundel (1983) illustrates the importance of productivity and effectiveness in the work environment.

The activities performed in the study to address the objectives.

Mundel (1983) defines productivity and effectiveness as follows:

- Productivity is the ratio of outputs produced per unit of resources consumed. The author states that the standard of living can be raised only if productivity is raised. Effectiveness relates to how well the outputs produced accomplished the intended purposes. According to Mundel (1983), low effectiveness accompanied by high productivity is less undesirable than low effectiveness with low productivity.

Tables 2 and 3 illustrate the purpose of measuring productivity. Table 2 illustrates an example of a typing pool, the dimensions, and corresponding goals. Table 3 illustrates an example of the time of a guard assigned to a specific post work.

#### Table 1. Subdivision of the time spent on a construction operation (Allal and Edmonds, 1977)

<table>
<thead>
<tr>
<th>Total time for the operation</th>
<th>Operational time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method time</td>
<td></td>
</tr>
<tr>
<td>Purely productivity time</td>
<td>Method time</td>
</tr>
<tr>
<td>Site time</td>
<td>Breakdown time</td>
</tr>
</tbody>
</table>

#### Table 2. Example with goals (Mundel, 1983)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of requests for typing served</td>
<td>100%</td>
</tr>
</tbody>
</table>
Timeliness of typical service

Correspondence: by the next day

Reports: by a given deadline

Quality of typing

0% return for redoing

Productivity increase

5%

Table 3 The time of a guard assigned to a post (Mundel, 1983)

<table>
<thead>
<tr>
<th>Total payroll time</th>
<th>2080 hrs/yr</th>
</tr>
</thead>
</table>

Deductions from the available time

| Sick and annual leave       | (261) |
| Physical fitness at 1 hr/day | (293) |
| Small arms practice at 2 hrs/m | (24) |
| Total deductions            | (592) |
| Total available for the post | 1488 hrs/yr |

Therefore, based on Table 3 above, it is concluded that the number of staff required per post should be calculated as follows:

Standard time per post = Days /post X Hours/day

Staff hours available/guard

= 365 X 24 = 5.89 staff yrs/post

1488

2.3 Roads and redistribution (Irvin & Irvin, 1975) The objectives of the study

In order to help with the execution of such policies and procedures, this study offers comprehensive tools to enhance the labour force in developing countries. The study focused on the following nine major projects:

- Technology and jobs
- Income distribution and jobs
• Population and jobs
• Education, skills and jobs
• Rural job outreach
• Urbanisation and jobs
• Emergency job schemes
• Internal and international migration
• International division of labour

International Labour Office (ILO) initiated a several road construction case studies in Iran that this study is based. According to the study, most of the road construction in Iran is capital intensive, and the focus was to investigate the technical feasibility of how far labour can be made to substitute for equipment and cost-benefit analysis. The study indicated that there could be reduced equipment usage, and significantly increase employment when adopting more labour-intensive techniques in the road construction.

2.4 The productivity prescription (Bain, 1982)
According to the study, government leaders in the United States view improved productivity as critical to balancing the budget, eliminating trade deficits, conserving scarce resources, and improving services provided.

The objectives of the study
This study is about how managers can analyse productivity problems, measure productivity and motivate employees to new heights of productivity. The study analysed managers, unions and non-unions of small and large industries and recommended implementable programmes for improving quality, service, and profit. According to the study, if we want to improve productivity in the years ahead, the following are key:

• Analysing the impact of the organisation on the individual.
• Examining the conditions under which the organisation is a threat to the individual and means of minimising such threats.
• Discovering how to design organisations and systems in a way that individual talents are utilised to the maximum.
• Preserving human satisfaction and dignity.
• Learning how to make technology serve people.
Bain (1982) illustrates that production, performance, cost, and results are not singularly equivalent terms, but there are the capacities to utilise existing resources to meet the ever-expanding demand of the individual. He discovered that in many industries, productivity has fallen, costs have steadily risen, and wages have increased while the output has declined.

According to the study, to realise an improvement in productivity, a manager should affect at least one of the following factors:

- Methods and equipment – eliminate waiting time.
- Utilisation of resources capacity.
- Performance levels – employees should accept organisational goals as their own and design training programmes for employees.

2.5 Manual on the planning of labour-intensive road construction (Allal & Edmonds, 1977)

This study is mainly for people engaged in planning, evaluating, designing, and implementing road projects.

The objectives of the study

The study emphasised the importance of implementing road construction projects using labour-intensive methods. A range of alternative technologies on road construction techniques and cost-benefit analysis are discussed. The study illustrates the type of management and the conditions of tender and contract terms required when implementing labour-intensive construction.

The study emphasises that the government department should know which roads should be maintained, at what intervals and the extent of maintenance operations. The study also indicates that if maintenance is not carried out to the originally designed standards, a road with a design life of ten years may have to be reconstructed after seven years. Therefore, the government should adequately budget for maintenance and ensure that budgets are spent on maintenance activities.

The study indicates that vegetation control and clearing of drainage systems are the two activities that should be considered when budgeting for maintenance.

Johannesburg Roads Agency Case Study (GTAC, 2015)

The City of Johannesburg (CoJ) founded the private company known as the Johannesburg Roads Agency (JRA) in 2000. JRA signed a service delivery agreement in 2001 that was reviewed in 2012 (JRA Strategy, 2017). The JRA has ten depots across seven regions in Johannesburg that are responsible for maintenance. There are two directorates that are responsible for all ten depots, namely Regional Operations and Mobility and Freight. The Regional Operations Directorate is responsible for nine depots, and the Mobility and Freight Directorate is responsible for one depot. The total number of staff in all the depots is about 1500 (JRA Strategy, 2017).

A diagnostic review of the JRA’s capacity and productivity of the in-house maintenance teams was conducted in 2015 by the Government Technical Advisory Centre (GTAC) in partnership with the Municipal Infrastructure Support Agent (MISA). The diagnostic review aimed to assist the JRA in improving operations management.
practices.

The following were some of the major findings of the JRA diagnostic report:

- Vandalism and theft of JRA infrastructure was a contributing factor that led to JRA not meeting its maintenance service delivery standard.

- Lack of capacity for in-house maintenance teams to attend to all the service requests within the expected and prescribed turnaround time.

- Lack of skills within the teams to adequately attend to service requests.

As much as vandalism and theft were believed to be significant contributors to the never-ending cycle of ‘replace and repair’ as indicated in the diagnostic review, the subjective evidence suggests that with JRA’s existing capacity, JRA should be able to speed up reaction times and increase the calibre of its work while handling routine tasks like pothole repairs, replacing manhole covers, restoring roads and installing signage and road markings.

3. Methodology
3.1 Qualitative

The subjectivist view of reality advocates appreciating human involvement in the creation and sharpening of knowledge (Jean 1992). According to Crotty (1998), the subjectivist epistemology holds that meaning or reality are imposed on an object by the subject, and in a research setting, the researcher. Qualitative research is more suited to the study of people and their environment rather than sciences (Bryman, 2001).

3.2 Quantitative

The positivist epistemology of inquiry is encouraged by the objectivist concept of an integrated and autonomous reality (Jean 1992). According to Jean (1992), the objectivist researcher strives to observe, measure, analyse and predict the relationship between reality components. Maguire (1987) indicated that the acquisition of data that can be measured and mathematically examined is crucial to the success of positivist research.

Therefore, the methodology adopted was influenced by the research aim and the type of data to be collected. The methodology utilised in this research was qualitative, with a number of interviews to be conducted and recording results on-site through a motion study survey.

A three-step research process was followed in this research. The first step included an extensive literature review thoroughly explaining productivity improvement in municipal road maintenance. This was in line with the problem statement, the research questions, and objectives. In the second phase of the research, an interpretative approach to knowledge was adopted. In phase three, to ensure validity and reliability, a structured questionnaire will be utilised for the participant to answer.

The on-site study will be done to record activities “as is”; this motion study will also ensure the reliability of information. Miller (1993) states that the Delphi Technique is a qualitative methodology that produces a consensus of a group of experts on an issue of concern through a survey consisting of rounds and based on a structured survey. Therefore, the structured questionnaire for this study is attached as annexure 4b.
3.3 Sampling Technique

The study’s panellists were chosen using criteria sampling as the selection method. Based on criteria created from the research topics under consideration, panellists were chosen to apply their knowledge to a concept raised in the study. A statistical sample that aims to represent any population is not necessary for a Delphi study. It is a process for group decision-making that calls for experts with in-depth knowledge of the problems (Okoli & Pawlowski, 2004). The selection of qualified experts is, therefore, one of the most significant needs as it is the most crucial element in the entire Delphi process and immediately affects the calibre of the results produced (Hsu & Sandford, 2007). Heads of departments, depot managers and foremen were selected because they are knowledgeable about the road maintenance process. They also provided a comprehensive picture and understanding of the road maintenance process within the municipal environment. Their personal views/opinions/experiences contributed to improving the current roads maintenance process.

3.4 Sample Size

The choice of the appropriate experts (panellists, participants, or responders) is a crucial component in using the Delphi interview technique, their contribution is crucial to the research’s success. (Hasson et al., 2000). Ten (10) to 15 panellists, as suggested by Delbecq et al. (1975), could be adequate if the backgrounds of the panellists are homogenous. A sample size of ten (10) panel of experts was adopted for this study, which consist of five (5) from JRA and five (5) from eThekwini Metro.

3.5 Research Method Employed

“The choice of a method has to be supported by the statement of assumptions that have been brought into the research process and are reflected in the methodology” (Crotty, 1998). These assumptions, though varied, tend to fall into the philosophical areas of ontology and epistemology. Therefore, one dimension of ontology (subjective) played an essential role in the epistemology, and ultimately, the qualitative methodology was chosen for this research. The Delphi method was used during the second stage of the study to identify the main attributes that bring about the development of the road maintenance framework. It also examined whether the attributes that determine productivity improvement by outsourcing maintenance to the private sector, as identified from the literature, are the same within the internal municipal maintenance teams.

3.6 Research Area of Focus

The research focused on the two metropolitans eThekwini metro and CoJ. There are seven (7) depots per metro, and the plan is to focus on two (2) depots per metro. The proposed depots to be selected will be those with a higher rate of unattended roads maintenance defects.

3.7 Selection of Participants

The participants were selected was based experience, seniority and knowledge of the road maintenance industry. The selection of participants was purposive to ensure the representation of important elements of the research question. Heads of departments, depot managers and foremen were selected because they are knowledgeable about the road maintenance process. They also provide a comprehensive picture and understanding of the road maintenance process within the municipal environment. Their personal
views/opinions/experiences will contribute to improving the current roads maintenance process. Table 4 below illustrates the summarised proposed research methods utilised in the study when performing a desk-top or field analysis.

<table>
<thead>
<tr>
<th>Research Objectives</th>
<th>Study Type</th>
<th>Method</th>
<th>Data Collection</th>
<th>Data Analysis &amp; Analysis Tools</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine the effective way of utilising municipal internal capacity in roads maintenance.</td>
<td>Field Study</td>
<td>Mixed Method</td>
<td>Focus Group Interviews</td>
<td>Thematic Analysis</td>
<td>Critical analysis of internal staff vs external services providers</td>
</tr>
<tr>
<td>Determine the best utilisation of road equipment and material within the roads maintenance to increase productivity</td>
<td>Field Study</td>
<td>Mixed Method</td>
<td>Focus Group Interviews</td>
<td>Thematic Analysis</td>
<td>Examination and analysing the utilization of road maintenance resources</td>
</tr>
<tr>
<td>Analysing and recommending the time it should take road maintenance teams to attend to road infrastructure defects.</td>
<td>Desk-top Study</td>
<td>Qualitative</td>
<td>Focus Group Interviews</td>
<td>Thematic Analysis</td>
<td>Assessing teams when attending to service requests</td>
</tr>
<tr>
<td>Recommending training and areas of development for municipal maintenance teams</td>
<td>Desk-top Study</td>
<td>Qualitative</td>
<td>Focus Group Interviews</td>
<td>Thematic Analysis</td>
<td>Identification of the required skills for roads maintenance</td>
</tr>
</tbody>
</table>

4. Results and Discussion
The main emphasis will be on the fundamentals of productivity improvement, including routine planning of maintenance activities, measuring the process and the areas affecting production, and analysing all the work-related elements of road maintenance (such as pothole repairs), which will result in the implementation of maintenance at a reasonable cost. The findings of this study should lead to recommendations for increasing of internal metro maintenance personnel, for internal staff training and areas of development, for decreasing external contracting out of road maintenance, and for internal teams’ operational effective and efficiency.

4.1 Scheduling and maintenance planning

To investigate internal municipal maintenance resources versus external service providers will include scheduling and planning of maintenance by internal municipal teams. The diagnostic analysis of JRA found that reactive maintenance now interferes with planned maintenance activities. Therefore, the study will, identify the problem's underlying cause and make additional suggestions for balancing planned and reactive maintenance in these metro areas. This will be done as follows:

4.1.6 Looking into ways to let some maintenance staff perform reactive maintenance while others perform preventive maintenance.
4.1.7 Looking for ways to implement a suitable split between proactive and reactive maintenance personnel between the two metro areas.
4.1.8 Examining strategies to improve the metro's present routine maintenance plans while considering the available resources.
4.1.9 The study will also look into how the metros might choose a system for dividing resources across maintenance teams that is more efficient.

4.2 The co-dependence of maintenance depots with Plant and equipment

A lack of spare parts for small plants and equipment is one of the reasons limiting the effectiveness of the in- internal municipal maintenance staff, according to research looking at how maintenance equipment and plants are used within the depots. Additionally, equipment and yellow plant (such as TLBs and Excavators) may have to wait for imported parts, which may result in equipment standing idle for an extended period. In order to improve the working relationship between plant depot (that provides equipment for maintenance) and maintenance depots, the study will investigate the following:

4.1.10 A method for the efficient use of plant and equipment by maintenance depots.
4.1.11 A strategy for the needs of the fleet and plant.

4.3 Motion study

There is no proof that any of the metros conducted a scientific research to measure the amount of time required to respond to calls for services for road infrastructure repair while assessing turnaround times. Additionally, there is no proof of the study on the internal municipal maintenance personnel’s ability to handle service demands. As part of the study, the following will be addressed:
4.1.12 Calculating the average response time to respond to inquiries in order to gauge each operating team's current performance levels.

4.1.13 Creating targets for achievement for individuals or teams based on the improved work processes for maintenance operations.

4.1.14 Recording each process's enhanced work procedure and the standard resource requirements accompanying them.

4.1.15 Creating a plan for road repairs.

4.1.16 Determining the hands-on training needs for managers, supervisors, and foremen in order to apply the enhanced work processes.

4.4 Training and areas that require development

Studies looking into the necessity for internal repair teams' skills development revealed that the labour-intensive repairs associated with paved roads outweigh those associated with gravel roads. According to Irvin and Irvin (1975), the ineffective administration of the staff turnover and recruitment processes is to blame for the decline in the number of employees in the government. Additionally, when employees leave the municipalities, management does not promptly request placements. JRA has not provided training and development for new hires or current employees in over five years, which could be the reason why the organisation is not achieving its service delivery standards. (GTAC, 2016). The study will focus on the following:

4.1.17 Examining the execution of a hiring strategy.
4.1.18 Advising all repair crews to undergo the essential skills development.
4.1.19 Examining if a skills development centre should be on-site.

The above describes the results of a pilot study and the intended methodology for a more in-depth study.

5. Conclusion

According to studies on South African metro areas, the majority have trouble meeting their service delivery goals for in-house maintenance because, for example, (a) money for road resurfacing and upkeep is inadequate; (b) some depot supervisors lack the necessary skills; (c) customer inquiries are handled more slowly; and (d) the job openings in the municipality are high.

According to Holzer and Seok-Hwan (2004), the productivity is a result of a number of factors, including the following:

• Senior management support
• Committed staff across the board
• Performance measurement system
• Staff development
• Renumeration structures
• Involvement of stakeholders and feedback for optimal budget-management

Furthermore, Linna et al. (2010) stress the necessity of an effective government for a prosperous community.
The goal is to guarantee that everyone involved in road maintenance, from managers to general workers, supports increased production and efficiency.

The purpose of the study is to improve productivity in road maintenance utilising municipal internal team of JRA and eThekwini Metro. Therefore, the in-depth study need ensure that it receive support from the top management from both JRA and eThekwini Metro for it to be successful and achieve the intended purpose.

6. **Acknowledgment**
Authors are grateful to University of Johannesburg for funding this research.

7. **References**


Closing the Gender Gap: An Investigation of the Feminine Paradigm in the Architectural Design Firms

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ABSTRACT
Purpose:
This research investigated how the gender gap can be closed so that discrimination against women can be eradicated in architectural design firms (ADFs) to promote equality and improve the working environment for all women in the architecture field.

Design/methodology/approach
A qualitative deductive research approach composed of a literature review and case studies was developed to accomplish three objectives. Firstly, build a comprehensive background about the research topic through reviewing literature related to the nature of work in ADFs, and discrimination against women in construction and ADFs. Secondly, present and analyse three case studies to study the strategies that eradicate discrimination against women in ADFs. Finally, the literature output was compared with the case studies to validate the relationships proposed between types, causes, impacts and strategies of discrimination against women.

Findings
The research revealed that the main causes of discrimination against women in ADFs and the construction industry are the underestimation of females working ability, long working hours, preferring to recruit males rather than females. In addition, women shifting their careers or leaving their profession and decrease in productivity are the common impacts of discrimination.

Research Limitations
The research is theoretically based. Data availability in the specific discipline of architecture was also one of the concerns.

Originality/Value
Previous research focused on identifying the causes, impacts as well as the strategies separately. However, this research aims at presenting a relationship between these different aspects. The developed relationship matrix can be further developed into a framework that can be applied at managerial level within the ADF to promote gender equality.

Keywords: Architecture design firms; construction industry; discrimination; gender diversity; woman.
1.0 Introduction

Women, who constitute about 50% of the world’s population play a significant role towards the social and economic development of countries worldwide. Discrimination against women threatens the survival of women in ADFs which leads to the deterioration of the number of female architects and hence affects the growth and prosperity of the architecture engineering profession (Tether, 2016). In 2021, 60 per cent of the students that joined the faculty of architecture internationally were females. However, when it comes to working in the field only 17 per cent of the world's architects are females (Barry, 2021; Waite, 2021). Chatterji (2021) mentioned that there is a huge gap between the number of female students in architecture and the actual number of females working in the field. He also asked a critical question “Where are the women in architecture?”. Women face many challenges in ADFs such as workplace discrimination, unequal wages, sexual harassment, and unsafe working environments, which leads them to leave the field resulting in the gender gap. Kumar (2013) specified that the number of women in ADFs is shrinking due to the unequal number of promotion opportunities given to males compared to females and the difference in wages. Furthermore, Jahn (2009) found that women in architecture are victims of unequal salary, discrimination, unfair treatment and disrespect and that women are judged from the moment they enter the field. Females are also not given their complete rights and are treated unfairly compared to males in ADFs. Moreover, if a woman can tolerate all the negative aspects in the field and reach a high position in ADFs, they are underestimated and undervalued by their male colleagues (Barry, 2021). Women also lack female architects who can mentor and guide young women entering the field which leads to a lack of female role models in ADFs. In spite of the national and international strategies developed to eradicate women's discrimination, the issue of discrimination still exists. Accordingly, this research aims to close the gender gap by investigating the feminine paradigm in ADFs in Egypt.

2.0 Discrimination against Women
2.1 The Nature of Work in ADFs

ADFs are a critical component of the construction industry. They typically involve a collaborative effort between architects, engineers, and other professionals to provide communities with projects and infrastructure facilities that meet their needs and expectations. The work involves designing and planning buildings and structures, considering factors such as aesthetics, functionality, safety, and sustainability. In addition, they contribute to economic development by creating employment opportunities and increasing countries’ Gross Domestic Product (GDP) (Khan, 2008; Essam and Ehab, 2015). The work can be both artistic and technical, requiring a strong understanding of design principles, building codes, and materials. Communication and project management skills are also crucial in ensuring the successful completion of projects within timelines and budgets. The design process at ADFs is complex, creative, and time-consuming (Othman and Abdelwahab, 2016). Accordingly, architects require high levels of tolerability, communication, and social skills. They must have patience as clients may change designs multiple times. They must stay updated with the latest software to remain competitive and increase their value in the industry. Additionally, architects must visit the site frequently to ensure their designs are being followed correctly (Tobias, 2019).

2.2 Definition and Types

Discrimination is the unfair or prejudicial treatment of people and groups based on characteristics such as race, gender, age, or sexual orientation (American Psychological Association, 2023). It is considered a negative way of treating people that may lead them to face psychological problems. Discrimination also acts as a barrier to achieving equality, peace and development. People suffer from different types of discrimination based on gender, age, colour, religious beliefs, race, etc. Gender discrimination means unequal treatment of a person or group of people based on gender. Sexual harassment is the most common example of discrimination against women (Pokharel, 2008). Furthermore, gender discrimination acts as an important obstacle that negatively affects the capacity of women to participate in society thereby affecting the economy of the country (Georgieva, 2022).
UNISON, the UK's largest union and equality and human rights stated in 2020 that there are four types of discrimination against women:

- Direct discrimination: The way someone treats a woman less favourably because she is a female.
- Indirect discrimination: When the employer releases a rule that is more biased toward men.
- Harassment: Undesirable behaviour either verbally or physically towards a woman that leads her to feel uncomfortable.
- Victimisation: When someone treats a woman less favourably because she has previously complained of discrimination or supported another woman who was exposed to discrimination.

2.3 Causes of Discrimination against Women

A major international humanitarian agency stated that the causes of discrimination against women are:

- Poverty as poor parents prefer to send their boys to school rather than girls to minimise the expenses (CARE, 2018);
- Lack of education which leads to inadequate awareness of women’s rights (CARE, 2018);
- The dominant social and cultural norms that force females to be subservient to males and dependent on them (Mukherjee, 2015);
- Social customs, practices and beliefs that lead people to think that women are inefficient at work and that males are more convenient than females (CARE, 2018);
- Sexual harassment that makes women feel uncomfortable (Barnabas et al., 2009);
- Working for long hours put women under huge stress especially since they are committed to other responsibilities such as their families so dealing with both is difficult (CARE, 2018);
- Preferring males to be recruited and trained rather than females allow women to feel undesired in this field (CARE, 2018);
- The huge gap between the wages of males and females makes them feel undervalued;
- Underestimating women’s work affects their feelings and may cause them to feel depressed and uncomfortable (UNAIDS, 2020).

2.4 Impacts of Discrimination against Women

Barry (2021) stated that when discrimination against women happens in ADFs, the following impacts take place:

- Women are obliged to either leave their profession and stop working or to shift their careers;
- Decreases the economy of the country;
- The architectural profession will lose women which is very crucial because they provide a wider perspective that makes both genders produce diverse creative innovations and solutions with different experiences and points of view and balance in the working environment that will allow better productivity and better achievements;
- Decrease in the profit of the firm after losing diverse viewpoints and opinions;
- Worsen the firm’s market reputation since the lack of women will confine the firm's designs, resulting in failure to meet the client's expectations for the design phase and client loss; and
- Decrease in productivity.

Manuk (2022) added some psychological impacts for females who experience discrimination:

- Depression;
- Undervalued;
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Disappointment; and
Career discouragement.

2.5 Discrimination against Women in the Architectural Engineering Profession

Females in the construction industry, whether being a part of a specialised team, or even working on site, suffer from biased treatment, disrespect and discrimination. Not only this but also differences in salaries between both genders and discrimination in promotions (Jahn, 2009) and also in indirect ways such as underestimation and segregation. Barry (2021) stated that the number of females in architecture is at an alarming low rate as they leave the profession due to barriers that strongly oppose their career which causes a loss of energy and talent. However, if a woman tries to sustain her job, she faces underestimation and underappreciation from her colleagues.

2.5.1 Women in the Construction Industry

Weidl (2014) mentioned the percentage of females working in the field worldwide and that Africa has the lowest percentage of females working in the field, but everyone concerned about this topic agreed that the female percentage in most of the world in construction is at risk, as shown in Figure 1.

![Figure 1. Percentage of women in construction (Weidl, 2014: 1)](image)

Naoum, et al. (2020) shed light on a huge concern that the percentage of females in construction is declining as they get older and as they spend more time in the construction industry. This results in severe skills shortages in the industry. The reason behind this is discrimination against women, which played a crucial role in women leaving the field while as they grow older. However, males do not face this sort of discrimination, and their percentage is almost the same by the time they get old as shown in Figure 2.
According to Miller (2021), unequal pay between genders is one of the barriers that women face in many industries, with firms in the construction industry being the biggest contributor to the unequal salary ranges between males and females by paying males more than the average of the job’s normal salary per hour, as shown in Figure 3.

2.5.2 Women in architecture
Tether (2016) mentioned that women suffer from an inflexible working environment in architecture and this is clear in Figure 4 which shows a worldwide statistic of how far ADFs permit a flexible working atmosphere. The Middle East and Asia ranked first worldwide with 73% of females suffering from inflexible working conditions. In addition, when comparing males and females that work in the inflexible workplace in the same area such as the UK 31% of males suffer from an inflexible working environment however 44% of females suffer from an inflexible
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workplace.

Figure 4. Workplace permits flexible working (Tether, 2016: 1)

In terms of training, males were favoured to receive training over their female counter parts which is gender discrimination in the workplace (Tether, 2016) as indicated in Figure 5. In the Middle East 31% of ADFs prefer training males rather than females, 4% prefer training females more than males and 65% do not take this area into consideration.

Figure 5. Favouring men more than women to train (Tether, 2016: 1)

Women also suffer from discrimination in promotion in the ADFs around the world as 67% of ADFs are not fully accepting of the concept of female architects having authority. 72% of female architects around the world have experienced sexual harassment through their work, with 33% of the female architects in the Middle East experiencing sexual harassment (Tether, 2016).
Furthermore, in terms of the gender pay gap within the architectural discipline, the RIBA report (2018) highlights two main reasons for this gap:

- Senior roles were usually occupied by males who were better paid; and
- Women occupy lower-paid administrative and support roles or occupy junior positions.

The American Institute of Architects (AIA) stated that both males and females view earnings/salaried as integral to career success. Therefore, the lack of compensation (in the form of pay, promotions, opportunities, professional development, and meaningful work) is the predominant reason why both men and women leave jobs in architecture or leave architecture altogether. AIA found that the average salaries for men are higher than women at every year of experience, with an average starting pay difference within a few thousand dollars, then increasingly diverging to approximately a 15% pay gap later in their career. Which is a clear indication of gender discrimination.

2.6 Strategies to eradicate discrimination against women in architecture

The International Union of Architects (UIA) (2017) and Derbyshire and Bacon (2018) mentioned that some strategies need to be followed to reach an environment free of gender discrimination in ADFs, which are:

- To divide the opportunities between all architects equally without looking to colour, age and especially gender;
- To deliver the value of women in leadership roles and to increase the awareness of the importance of female roles in the field;
- The HR team should work to reach equality by ensuring that females are treated, recruited and selected for promotion and training on a similar basis as males;
- The member section should keep in mind that females are less tolerating than males to follow traditional career paths so it should provide a flexible working environment, appreciation rewards and career progression to females similar to males;
- Encourage the formal cross-gender relationship to allow both genders to acquire experience from each other without preferring any gender to be more experienced and qualified than the other;
- Develop cultures and policy of the firm that was long-listed by males and raise awareness of the invisible barriers that opposes gender equity;
- Provide an accessible channel for females to provide concerns or complaints to be solved and reach gender equality;
- Provide salary according to the position and experience of that employee and not according to their gender.

3.0 Research Objectives and Methodology

This research investigated the discrimination against women in ADFs with the aim of identifying relationships between causes, impacts and solutions to close the gender gap in the industry. Due to the nature of this research, a qualitative and deductive approach based on a literature review and case studies was adopted to achieve three objectives.

- First, reviewing literature review to build a comprehensive background about the research topic by covering the nature of work in ADFs, types, causes, impacts and strategies for women discrimination in construction and ADFs.
- Second, presenting and analysing three case studies to study the strategies that eradicate women
discrimination in ADFs.

- Finally, comparing the literature review output with the case studies output to validate the relationships proposed between types, causes, impacts and strategies of discrimination against women.

3.1 Relationship between causes, impacts, strategies and types of discrimination against women

In order to correlate the outcome of the literature review, Table (1) shows the relationship between causes, impacts, strategies and types of women discrimination in ADFS.

Table 1. Matrix of causes, impacts, strategies and types of Women Discrimination identified from literature

<table>
<thead>
<tr>
<th>Impacts of Discrimination against Women</th>
<th>Strategies</th>
<th>Type of Discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of different perspectives</td>
<td>Increase the awareness of the importance of female’s role</td>
<td>Indirect Discrimination</td>
</tr>
<tr>
<td>Decrease in economy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shift gender issue of the professional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease in productivity</td>
<td></td>
<td></td>
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<tr>
<td>Decrease in profit</td>
<td></td>
<td></td>
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<tr>
<td>Bad reputation</td>
<td></td>
<td></td>
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<tr>
<td>Score</td>
<td></td>
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<tr>
<td></td>
<td>4/6</td>
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</tr>
</tbody>
</table>

3.2 Case Studies
Case Study Definition and Selection Criteria

Case study is a research technique used in different research disciplines to analyse and describe an event or subject, with the goal of classifying different variables and relations between various factors or evaluating performance (Starman, 2013). Three case studies from different countries were selected to understand the discrimination against women in different cultures and traditions and to see how this was addressed. Due to the limited published work on discrimination against women in ADFs, 2 cases represents ADFs while the third case was from a construction company. The case studies’ selection criteria were based on the nature of the selected firms, data availability, degree of success and location. These cases were analysed by comparing between the background, causes and impacts of women discrimination and the adopted strategy in each case. These cases were analysed based on comparing between the background, causes and impacts of women discrimination and adopted strategies for eradicating women discrimination in each case.

3.2.1 Case Study 1: HMC Architects

(a) Background
HMC Architects is an architecture design firm that was first created in California then expanded worldwide. This firm found the problem of discrimination against women in their offices and decided to take steps to ensure gender equality (Manuk, 2022).

(b) Causes of discrimination against women within the company
HMC Architects noticed that there was a difference in salaries between both genders which made women feel undervalued and underestimated. The female architects in the firm also felt uncomfortable because they felt that the firm was male-dominated. Moreover, HMC found discrimination in promotion, recruiting and training as women are mostly neglected in these processes because managers that were often males preferred choosing male staff. In addition, due to some customs and traditions women were refused to have authority over males which drove females to feel that they were secondary. Furthermore, the field forced architects to work for long hours which is hard for women to cope with as they have their own life and family (Manuk, 2022).

(c) Impacts of discrimination against women within the company
Manuk (2022) stated that as a result of the discrimination against women, a sheer number of women left their professions or shifted their careers. In addition, the firm lost a variety of different opinions and viewpoints as the presence of women increases the level of creativity and innovation for design problems. Furthermore, the absence of women decreased the productivity of the firm.

(d) Strategies that eradicate discrimination against women in the company
HMC educated their younger staff to see females as part of the team and that it is normal for any architect (whether male or female) to have authority over them. HMC also increased the awareness of women and the importance of their role in the firm. The female architects were also given equal salaries and the same opportunities as their male counterparts (Manuk, 2022).

3.2.2 Case Study 2: McMillan Pazdan Smith Studio

(a) Background
McMillan Pazdan Smith is a studio for architecture, interior design and planning firm located in 8 different countries...
which are Colombia, Augusta, Atlanta, Charlotte, Asheville, Charleston, Spartanburg and Greenville. They work to design a better future through innovative and creative designing solutions and this cannot be done without well-chosen staff with high qualifications whether females or males (Smith, 2023).

(b) Causes of discrimination against women within the company
McMillan Pazdan Smith studio found out that their productivity and profit were reducing and when they investigated the problem, they found out that one of the reasons for this problem was discrimination against women. The primary cause was inflexible working hours that put too much stress on women. Mothers needed to be with their children at certain times but long working hours prevented them from doing this and they also faced a problem of child care during the long hours they were at work. McMillan Pazdan Smith also saw that women were being discriminated against by preferring to recruit, train and promote males rather than females. Customs and beliefs and underestimating women also played an important role in discrimination against women in the firm as male architects refused the ideas of women and refused to accept the authority that female architects had over them. The males in McMillan Pazdan Smith also believed that women were not qualified enough for high positions (Smith, 2023).

(c) Impacts of discrimination against women within the company
Smith (2023) stated that when interviewed some of the women in the firm mentioned that they faced sexual harassment and that made them feel insecure, depressed, undervalued and disappointed. Not only this but also the firm and community get affected as the firms profit and productivity decreases as women leave their profession or change their careers. The firm also developed a bad reputation.

(d) Strategies that eradicate discrimination against women in the company
In order to eradicate discrimination against women, McMillan Pazdan Smith started providing flexible working hours for both women and men to reduce stress levels while working. They also provided a policy which contains a bank of hours for employees which means that they work a specific number of hours that can be used during the working week as they desire to increase work flexibility. In addition, a nursery was provided inside the firm for women to leave their children while they were working to give them a full opportunity to work without worrying about their kids. Furthermore, women are being promoted, recruited and trained similarly to males (Smith, 2023).

3.2.3 Case Study 3: Laing O’Rourke

(a) Background
Laing O’Rourke is an Australian Dartford-based construction company and was founded in 1978 by Ray O’Rourke (Varley, 2018).

(b) Causes of discrimination against women within the company
Varley (2018) mentioned that women faced 2016 a huge salary gap compared to men not only this but also the offer applied to new architects differs based on their gender not on their experience as they are underestimated. Moreover, when it comes to hiring and recruiting new architects they prefer recruiting males as only 30% of the newly hired people are females. Furthermore, females were not given the full opportunity of a flexible working environment such as males.

(c) Impacts of discrimination against women within the company
Varley (2018) stated that women are severely affected by the causes of female discrimination in the firm as they feel depressed, underestimated, undervalued and discouraged which leads them to leave the profession or shift their career. Based on this, the firm loses diverse perspectives that will reduce its productivity and profit and will lead to bad reputation in the marketplace.

(d) Strategies that eradicate discrimination against women in the company

Varley (2018) mentioned that the company used some strategies to eradicate women discrimination inside the firm such as reaching pay equity as of 2016, they found out that women suffer from unequal pay compared to men so they made a campaign to increase all the females’ wages to be equal to males. In addition, it was clear to the firm, after an investigation that they had gender inequality in their workplace, so they made some other strategies to reach equality between both genders which are work flexibility not only for males but also for females, making a specific programme for females to encourage and support them if they faced any women discrimination.

4.0 Results

Based on the above analysis of the case studies, it can be concluded that underestimation of females working ability, long working hours, preferring to recruit males rather than females are the main causes of discrimination in all three cases. These findings are in line with literature review. For example, Gosavi (2019) stated that women are less employed in ADFs due to the preference of ADFs to hire men due to their flexibility and ability to handle quick confrontations. In addition, working in ADFs requires architects to work long hours, which can be difficult for females who need to return home to their families. Moreover, women are often criticized for spending time in trivial conversations which lead to gossip and tension within the design team and affects the working environment and productivity. The common impacts of discrimination in the three case studies could be summarised as women shifting their careers or leaving their profession and a decrease in productivity. These impacts are in line with literature review which stated that women discrimination plays a role in demotivating women towards completing their duties and reduce their performance. This affects both the individual employee and the organization. Moreover, each case study has its strategy to address the causes and impacts of female discrimination.

Furthermore, the results of the case studies were compared in Table 2 to that of the literature and relationships were concluded validating the literature output.

Table (2): Literature and case studies comparison.
5.0 Conclusion and Recommendations

Women constitute a sizable proportion of the world population and contribute significantly towards the social and economic development of countries worldwide. Discrimination against women in ADFs is a serious problem that threatens women's careers in the architecture field and the construction industry. In 2021, it was estimated that 60% of worldwide architecture students are female, while just 17% of them joined the profession. The gender gap in ADFs is growing as a result of workplace discrimination, unequal salaries, sexual harassment, and hazardous working conditions. Women confront obstacles such as unequal promotion and income prospects, as well as unequal pay, discrimination, unjust treatment, and disrespect. They are frequently judged from the minute they reach the field and are not allowed full rights. Furthermore, women are frequently devalued and underestimated by their male co-workers. Furthermore, there is a scarcity of female architects to mentor and guide young women joining the sector, resulting in a gender gap.

This research focused on examining how the discrimination against women can be eradicated in ADFs to promote equality and improve the working environment for all women in the architecture field. This aim was achieved through a qualitative deductive research approach composed of literature review and case studies to accomplish three objectives. Firstly, building a comprehensive background about the research topic through reviewing literature related to the nature of work in ADFs, types, causes, impacts and strategies for women discrimination in construction and ADFs. Secondly, presenting and analysing three case studies to study the strategies that eradicate discrimination against women in ADFs. Finally, the literature output was compared with the case studies output to validate the relationships proposed between types, causes, impacts and strategies of discrimination against women. Results of this study showed that the main causes of women's discrimination in ADFs and the construction industry are underestimation, long working hours, and preferring to recruit males rather than females. In addition, women shifting their careers or leaving their profession and decrease in productivity are the common impacts of discrimination.

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
Based on the above conclusions, the research recommends that applying the strategies proposed by the International Union of Architects will help eradicating discrimination against women in ADFs. In addition, governmental support and persuasion of senior management in ADFs will enable achieving the objectives of these strategies. Moreover, working on changing the traditions and culture as well as community view to the women will contribute towards eradicating women discrimination in ADFs. Future research about developing a framework to overcome the causes and impacts of female discrimination in other countries will explore more approaches and strategies for empowering women in workplace.

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A Corporate Social Responsibility Framework for Achieving Sustainability in Construction Projects: The Architects Role in Egypt

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ABSTRACT
Purpose: This research aims to propose a corporate social responsibility framework for enhancing the role of the architects towards developing a sustainable construction supply chain in Egypt.

Design/methodology/approach: This research was conducted in three steps. Firstly, a comprehensive literature was conducted. The second step involved an in-depth analysis of a case study. Finally, the theory from the literature was compared with the case study in order to develop a corporate social responsibility framework for architects.

Findings: The unsustainability of the construction industry is a major problem that has significant impacts worldwide. This study developed a relationship between the architect’s role based on the corporate social responsibility concept and the causes of the unsustainability of construction projects. It was shown that architects have an environmental, social and economic responsibility towards a project that can be effective in enhancing the sustainability of the industry.

Research Limitations: The research is theoretically based where no observation on a practical level was done. This will form the next stage of the study.

Practical Implications: The developed framework can act as an action plan applied by architects to improve the sustainability of the construction industry.

Originality/Value: This research highlights the important role that architects play in terms of corporate social responsibility with the aim of solving the problem of unsustainability in the construction industry.

Keywords: Architects; Corporate Social Responsibility; Design Firms; Sustainability.
1. **Introduction**

The global construction industry (CI) has often faced criticism for its lack of sustainability (De Ridder and Vrijhoef, 2008). Within this industry, the chain of events is notorious for its unsustainable practices, with architects playing a significant role in this issue (Wibowo et al., 2018). Unsustainable elements such as excessive waste production, the utilisation of non-recyclable materials, and the inclusion of hazardous substances like silica are pervasive. It is evident that architects wield considerable influence over the CI process, starting right from the preconstruction phase. Moreover, architects possess the potential to either positively or negatively impact the overall sustainability of the CI, subsequently affecting the environment and thereby either enhancing or undermining sustainable standards. Given that architects are among the primary contributors within the CI (Wibowo et al., 2018), they hold a pivotal role in advancing building sustainability.

The incorporation of Corporate Social Responsibility (CSR) can significantly empower architects to bolster their role in driving sustainability within the field. By aligning with CSR principles, architects can steer sustainability practices throughout various phases—feasibility, preconstruction, construction, and post-construction. This holistic approach allows architects to contribute to sustainable CI through three critical dimensions: social, economic, and environmental considerations. Hence, the focus of this research centres on the integration of architect-driven CSR to effectively manage the CI, with the ultimate goal of reducing project costs, conserving non-renewable resources, and enhancing the quality of life for end-users.

2. **Research Method**

The objective of this research is to formulate a CSR-centred framework that elevates the architect’s contribution to achieving sustainability within Egypt’s construction industry. The method was conducted in the following steps:

- Establishing a robust foundation in the research domain by comprehensively addressing sustainability, CSR, the construction industry, and the pivotal role of architects. This was done through studying previous literature. Keywords used for research as “Corporate Social Responsibility AND Architecture Engineering AND Sustainability” “Corporate Social Responsibility AND Architects’ Role towards Sustainability”. After screening the resulted papers, the Architects’ Role in each of the sustainability domain was defined.
- Conducting a detailed examination and evaluation of a pertinent case study to delve into the impact of CSR on amplifying the sustainability of the Construction Industry (CI) through the architect’s involvement.
- Devising a cohesive CSR framework that enhances the architect’s role in fostering a sustainable CI, facilitated by the creation of a relationship matrix.
- Validating the framework’s efficacy by juxtaposing the findings from the literature review with the insights gleaned from the case study analysis.

3. **Literature review**

3.1 **Sustainability**

Sustainability is known as meeting the demands of the current generation’s without negatively affecting future generations’ abilities to fulfil their own needs (Kuhlman and Farrington, 2010). It seeks to provide products that improve the quality of life, satisfy customers, provide adaptability and flexibility to user changes, maximize resources efficiency, and support desirable natural and social environments (Raynsford, 2000). Sustainability is achieved by increasing resource efficiency and moderation in the use of energy, materials, and space development. Sustainability has three dimensions: the environment, society, and economy.

Sustainability refers to the social, economic, and also the environmental conditions that will allow humans to collaborate in ‘productive harmony’ with nature in the present and future (USEPA, 2009). Despite its important contribution to economic growth and social development, the CI consumes a large amount of non-renewable resources. It is a significant source of waste, air and water pollution, and land demolition.
According to a Dixon (2010), the CI accounts around 45-50% of global energy usage, close to 50% of water usage worldwide, and about 60% of total raw material usage (Othman and AlNassar, 2021). Furthermore, the industry contributes to around 23% of air pollution, 50% of climatic greenhouse gas emissions, 40% of contaminated drinking water, and another 50% of landfill debris (Dixon, 2010). The growing global awareness of sustainability and its contribution to environmental preservation, economic growth, and social advancement has prompted the building sector to consider sustainability (Abdellatif and Othman, 2006; Addis and Talbot, 2001).

Sustainability has three major aspects as shown in Figure 1, economic, environmental, and social aspects. The combination of these features resulted in three additional aspects, namely environmental-social, economic-environmental, and social-economic, all of which value the rights of all persons to a fair share of the environment’s natural resources at the national and even the international levels. This assures that a segment of society does not utilise these environmental resources, leaving the rest with needs that cannot be supplied by the world's remaining resources (Othman et al., 2014; Rodriguez et al., 2002).

Environmental sustainability contributes to minimising the use of non-renewable resources and environmental emissions, reducing environmental uncertainty and risks, minimising waste and pollution, reducing use of hazardous substances and encouraging the recycling and reusing of construction materials (Kim, 1998).

The social aspect concentrates on determining the stakeholders’ demands and ensuring that the created project fits those needs and expectations. Furthermore, it fosters participation and feedback from all parties that are influenced by the built environment, ensuring health and safety criteria are met, taking into account peoples need, and offering support and value to communities and the construction supply chain (Othman and AlNassar, 2021).

Economic sustainability promotes CI growth by boosting GDP through developing new markets and sales opportunities, affording additional job opportunities by cutting costs, improving efficiency and lowering energy and raw material inputs, and enriching client profit and investments return (Addis and Talbot, 2001).

Managing the social, environmental, and economic impacts, as well as the promotion of good corporate governance throughout the projects life cycles and services is important (Armenia et al., 2019). Suppliers in today’s business environment are handling on more responsibility to an effective design, manufacture, and
recall their products since the CI becoming more environmentally aware (Singh et al., 2023) and the industry is not just acting in its own interests, but also in the interests of its stakeholders' and of the society as a whole (Sisco et al., 2010).

3.2 Corporate Social Responsibility and the Architect

The integration of CSR within the CI encompasses various dimensions. For instance, numerous companies have taken significant strides to enhance the environmental sustainability of their projects. They've achieved this by implementing measures like the incorporation of renewable energy sources and the utilisation of eco-friendly construction materials. Nevertheless, a crucial aspect of optimising CI performance involves adeptly managing the supply chain of architectural firms. This entails diligently considering the reduction of reliance on unethical labour practices such as child labour and slavery.

Architects, bear a multifaceted responsibility: not only to their clients but also to society and the environment. In the context of the CI, architects hold a pivotal position as the primary point of contact for clients. This implies that their role should extend beyond technical functions, encompassing additional responsibilities aimed at enhancing the sustainability of the built environment.

In forging a connection between the architect's social role and sustainability, it becomes imperative to examine the architect's societal contributions from three distinct perspectives, as illustrated in Figure (2), environmental, social and economic responsibility.

A. Environmental responsibility

First and foremost, there's the environmental aspect, which centres around the preservation of natural resources. During the design phase, architects must meticulously consider the climate conditions of the host country. Othman (2009) stated that “it's essential to factor in the environmental impacts on the buildings and devise designs that align with these effects, taking climate constraints into account.” For instance, in Egypt's desert climate, constructing buildings with curtain walls might not align ethically with the environmental conditions. Summers that reach up to 43°C during the day could lead to escalated building costs and exert an economic impact on the project. Consequently, this economic influence cascades down to the construction supply chain's life cycle, subsequently affecting the project's environmental dimension. The responsibilities of Architectural Design Firms (ADF's) encompass optimising the utilisation of environmental resources to foster human development (Othman and AlNassar, 2021).

Furthermore, architects bear the responsibility of heightening community awareness regarding environmental conservation and promoting the incorporation of sustainable resources during the architectural design phase. As part of their corporate social responsibility (CSR) features, architects enact positive measures...
Architects have a responsibility to the environment, which can be summarised as follows:

- Raising awareness within the architectural profession of the importance of environmental preservation and actively encouraging utilisation and implementation of sustainability concepts in architectural designs.
- Reducing buildings' negative environmental impact by using long-lasting materials that are non-toxic, eco-friendly, energy efficient, easily maintained, and recyclable.
- Encouraging one’s design firm and others to be responsive in looking for ways to be more aware of their environmental responsibilities in their supply chains.
- Taking into account environmental effects on buildings and developing designs that adapt to these impacts (i.e., climate constraints).

B. Social Dimension
Second, the architects social responsibility is categorised mostly under the user and stakeholders need, in terms of facilities for people with special needs as well as health and safety requirements (Othman, 2009). Throughout the construction process, raising the labour awareness of taking the health and safety precautions, could save their lives which improves the CSR. Moreover, during the planning design process, taking into consideration the placement of ramps, elevators, lightening and doors sensor, and handrail, is from the architects contribution to the sustainability of CI. Architects have a social responsibility which can be summarised as follows:

- Raising awareness of the importance of the architect’s role in society.
- Identifying and comprehending the needs, habits, traditions, and cultures of clients and end-users, and ensuring that the developed design meets and reflects their requirements.
- Involving and soliciting feedback from people impacted by the built environment during the decision-making process.
- Ensuring that building users’ health and safety requirements are met.
- Ensuring that people with special needs were considered in the design.
- Aiding and adding value to communities and the supply chain, as well as encouraging supply chain members to do the same in their communities.
- Encouraging architecture schools to educate future architects about their social responsibilities and to provide expert advice to non-experts through volunteer services.

C. Economic Dimension
The rate of the CI demand has increased rapidly due to the increase in population (World Economic Forum, 2016). As a result, the demand of architects has increased, especially architects who relies on passive techniques through their designs. Designing a curtain wall façade in Egypt deserts is not an effective idea, as it will increase the mechanical engineers role for HVAC system in the project to enhance its interior air temperature (Othman and AlNassar, 2021)

Architects face the challenge that is defined by the creation of environments that support, enhance, and celebrate human activities. Cities, towns, and structures have always evolved because of economic, cultural, and social factors. This necessitates the architect taking responsibility for the factors that contribute to the design of a responsive environment. Architects have an economic responsibility, summarised:

- Emphasizing the importance of the architect's role in economic improvement.
- Ensuring that societal resources and funds are used effectively.
- Promoting and encouraging purchasing from supply chains that are focusing on enhancing sustainability of their products.
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• Considering the project's life cycle cost and reducing the maintenance and operational costs.
• Developing new innovative ideas and utilising sustainable materials that can perform the same function at a lower cost.
• Describing national manufactured materials to enhance the local market and lowering the cost of importing the materials.
• Using recycling demolition materials for the manufacture of new building materials.

4. Framework Development
To sum up, the literature investigates the perception and application of ADFs toward enhancing sustainability of CI using CSR. The previous section concluded with two important aspects which are the causes of unsustainability and the author perspective on the architects' role in each of the sustainability dimensions. A relationship output matrix (as shown in table 1) was developed to highlight the relationship between these two aspects; causes of unsustainability of CI and the CSR and the architect role in the environmental, social and economic aspect where it shows that the architect has a very active role in solving the unsustainability problem in the CI

3.3 Case Study: Ganda primary School Extension (Archdaily, 2016; Kere- Architecture, 2018)
This case study was selected as it shows the architects role in the three dimensions of sustainability. It shows that simple solutions presented by the architect can prevent the existence of unsustainability.

Located in Burkina Faso, Gando primary school was designed by Francis Kéré. The school was designed to meet the social and environmental needs of Burkina Faso local community.

3.3.1 Causes of unsustainability
While the Gando Primary School stands out as a pioneering model of sustainable community-centred architecture, certain factors could potentially pose challenges to its long-term sustainability. Several of these elements warrant consideration:

• Maintenance: Ensuring the continued functionality and preservation of the design, particularly the utilisation of regional materials, necessitates regular maintenance. Neglecting this aspect could gradually erode its sustainability over time.

• Environmental Changes: The school's design is intricately tailored to the unique environmental conditions of the Gando region. For instance, it effectively regulates temperature and conserves water. However, its effectiveness could diminish if the region undergoes significant and sudden environmental shifts.

• Access to Resources: The school's design hinges on the use of local materials and resources. Nevertheless, the intermittence or limited availability of these resources over time could pose challenges. If, for instance, there's a shortage of clay in the vicinity, maintaining or repairing the school might become notably more complex.

In essence, while the Gando Primary School showcases remarkable sustainable architectural principles, its enduring viability demands vigilant attention to these potential challenges.
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Table 2. Relationship Matrix derived from literature.

| CSR | Economic
| Natural resources consumption | Waste production | Unsustainable techniques | Cost (afford) | Climate changes (earthquake- forest) | Labour skills | Design errors | Labour consideration | Planning risks | Project life cycle | Quality | Project time | Material used |
|-----------------|-----------------|-------------------|------------------------|---------------|--------------------------------------|--------------|--------------|---------------------|---------------|-------------------|---------|------------|--------------|
| Natural resources consumption | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Waste production | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Unsustainable techniques | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Cost (afford) | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Climate changes (earthquake- forest) | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Labour skills | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Design errors | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Labour consideration | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Planning risks | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Project life cycle | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Quality | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Project time | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Material used | x | x | x | x | x | x | x | x | x | x | x | x | x | x |

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3.3.2 Architects social role

The school was designed by considerate, culturally aware, and socially conscious designers who sought to produce structures that addressed the particular needs of their communities while fostering sustainability, education and community engagement. The architect’s environmental, social, and economic aspects accomplished in the project are discussed below.

A. Architects Environmental Responsibility

A number of techniques were used to lessen the impact on the environment such as:

- **Use of regional resources**: The school was built using regional resources, including wood, mud bricks and stabilised handmade compressed earth blocks, which reduced the environmental impact of the building materials' processing and transportation.

- **Passive design strategies**: To minimise the need for mechanical systems and lower energy consumption, the school's design makes use of passive cooling, shading, and natural ventilation. The hot tin roof was pulled away from the interior perforated ceiling as part of the ventilation strategy (Figure 3) with the aid of perforated gaps design within the weave of the ceiling's brick pattern, which is shaded and shielded from damaging rain (Figure 3). Moreover, a central courtyard that offers a natural gathering place and ventilation chimney was also incorporated into the school's design.

Moreover, maximum ventilation was achievable by the interior windows use of shutters that enhanced the cross-ventilation on the northern and southern walls, drawing in cool air and the clay roof's perforations letting hot air escape. Additionally, by reducing the need for air conditioning, this significantly minimises the school's environmental impact.

- **Rainwater harvesting**: A system for gathering and storing rainwater was incorporated into the school's design. This water was then used for irrigation and hygienic purposes.

- **Solar energy**: To generate power for electrical needs like lighting, the school uses solar panels, as a means for reducing its reliance on non-renewable energy sources.

- **Waste reduction**: Composting toilets, as well as reuse and recycling waste materials systems, are part of the school's design, which helps to lower the amount of waste it generates.

With a focus on lowering energy use, minimising waste, and utilising renewable resources, the Gando Primary School's design as a whole shows an intense dedication to environmental sustainability. These methods not only lessen the school's environmental impact,
but they also provide a template for environmentally friendly construction methods in other settings.

**B. Architects social responsibility:**

The school's design by the architect included several social factors, including community involvement, accessibility, and cultural sensitivity. From the architect social responsibility achieved through the project:

- **Involvement of the community:** Local residents were given training and job opportunities during the school's construction, which included them in the building process. This strategy fosters a sense of pride and ownership in the school while also promoting the economic growth of the neighbourhood.

- **Accessibility:** The school's layout takes the students' needs into account, including those of students with disabilities. In addition to an open courtyard that offers a secure and accessible area for kids to play, and a ramp for handicapped access, (as shown in Figure 5)

  ![Figure 5: Disabilities Ramps as a social responsibility role towered the architects.](image)

- **Comfort and wellbeing:** The design of the school places a strong emphasis on the comfort and wellbeing of the students. This is done through incorporating elements that contribute to a comfortable learning environment, such as natural ventilation, lighting, and shading (Figure 6).

  ![Figure 6: natural lightening and ventilation strategies.](image)

- **Cultural sensitivity:** The design of the school, which honours the cultural heritage of the neighbourhood, incorporates traditional building methods and materials like wood and mud bricks. Local building practices were also incorporated into the design to guarantee that the building is suitably adapted for the climate.

Overall, the school's design demonstrated the architect's social responsibility through considering engagement with the community, accessibility, respect for culture, and comfort and well-being were taken into account. The architect designed a structure that not only meets the practical needs of the community but also promotes its social well-being by considering the building's social impact on its community.

**C. Architects economic responsibility:**
This was done through incorporating multiple financial considerations into the design of the building such as:

- **Cost-effectiveness**: The architect concentrated on lowering construction costs without compromising the building's quality or functionality. This was accomplished by utilising inexpensive building materials that were easily accessible locally.
- **Strategies for sustainable maintenance and operation** were incorporated into the school's design by including composting toilets and rainwater collection systems. These methods aid in minimising the building's ongoing maintenance and operation expenses.
- **Local economic development**: residents of the local community were given training and job opportunities during the school's construction.
- **Efficient utilisation of resources**: locally sourced labour and materials reduced the financial impact of the building materials' transportation and processing and labour costs.
- **Natural lighting and ventilation** were also incorporated into the school's design, which helped to lower energy use and related costs.

The use of affordable, environmentally friendly, and locally sourced materials and labour, which benefited the community economically, was one way the architect's economic responsibility was demonstrated overall. The architect designed a structure that not only satisfied the community's functional needs but also promoted its economic health by considering the building's economic impact on the surrounding area. To produce the best building solution for this project while facilitating construction and future maintenance, conventional building techniques and present-day engineering methods were combined. The close involvement of the local community in the construction process is responsible for the project's success.

5. **Framework Validation**

The research developed a relationship between the architect's role based on the Corporate Social Responsibility concept and the causes of the unsustainability of construction projects. A case study was used to validate the proposed framework by testing the relationship (Table 2). The results of the validation process ensured the correctness of the relationship.

**Table 2**: Comparison between literature output and Case Study output

<table>
<thead>
<tr>
<th>CSR</th>
<th>Economic</th>
<th>Social</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raising the awareness of sustainability concepts among local communities.</td>
<td>Reducing building costs through the use of local materials and labour.</td>
<td>Ensuring that the architect's role is strengthened in the decision-making process.</td>
<td>Minimising the environmental impact of the project.</td>
</tr>
<tr>
<td>Considering the importance of societal responsibilities and stakeholders' involvement.</td>
<td>Developing new innovative ideas and utilizing sustainable materials.</td>
<td>Considering the local community's feedback and involvement.</td>
<td>Ensuring the building serves the community and society.</td>
</tr>
<tr>
<td>Aiding the architect's role in the design process.</td>
<td>National manufactured materials to enhance the local market and reduce imports costs.</td>
<td>Promoting and encouraging recycling, demolition, and waste management.</td>
<td>Ensuring the building serves the community and society.</td>
</tr>
<tr>
<td>Enhancing the architectural design with handicapped-friendly construction.</td>
<td>Recycled materials and waste products used in the building.</td>
<td>Ensuring the building serves the community and society.</td>
<td>Ensuring the building serves the community and society.</td>
</tr>
</tbody>
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6. Conclusion and Recommendation

The research centres on the key pillars of the Construction Industry (CI) and their interplay with sustainability, the CI's nature, the architect's societal role, and Corporate Social Responsibility (CSR). The study elucidates how the architect's contributions across the environmental, social, and economic dimensions can be elevated through the application of CSR principles. By delving into the literature, the research identifies both the root causes and ramifications of CI's unsustainability. Moreover, it comprehensively elucidates the architect's multifaceted societal responsibilities spanning environmental, social, and economic realms.

In conclusion, the research presents a robust CSR framework capable of enhancing the architect's role in fostering a sustainable CI. This framework has been demonstrated through a case study that highlights the effectiveness of applying CSR to augment the architect's societal contributions, thereby fortifying the CI's sustainability. However, this study does face certain limitations, primarily stemming from constrained data availability. Furthermore, the framework's real-world application hasn't been empirically tested.

Considering these factors, several recommendations emerge:

- Conducting an extensive survey involving experts to ascertain additional causes of unsustainability and to propose more comprehensive solutions.
- Future investigations might focus more narrowly on specific risk types during the design phase for a deeper analysis.
- The research could be enriched by incorporating a broader range of case studies to further validate the relationship matrix and framework.
- The actual implementation of the framework presents a new avenue for critique, testing, and iterative development.

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ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
Why I registered for Construction Management

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ABSTRACT

Purpose of this paper
The aim of this research was to determine the reasons BSc undergraduate construction management students registered at Nelson Mandela University, including related issues, in an endeavour to improve career promotion interventions, and increase registrations for the programme.

Design/methodology/approach
The quantitative method was adopted, and the data was collected through the distribution of a structured questionnaire to BSc undergraduate construction management students at Nelson Mandela University. The data was analysed using MS Excel to generate descriptive statistics in the form of frequencies and means.

Findings
Potential students consider a range of programmes and apply to several universities; however, both the programme and university are important factors in terms of their final decision. The Construction Management programme is attractive due it being a vocational qualification, a business qualification, and the potential job opportunities. Although, there is a general interest in the built environment on the part of potential students, registered students envisage a career primarily in Construction Project Management and contracting (Construction Management).

Research limitations/implications (if applicable)
The study is based on a small sample, which may affect the generalisation of the findings.

Practical implications (if applicable)
Construction Management programmes compete primarily with Construction Economics and Civil Engineering programmes, and therefore the difference between the programmes should be made clear. A multi-pronged approach is required in terms of promoting Construction Management programmes, and a range of stakeholders need to contribute. The achievement of Construction Management graduates and their career paths should be used by a university to promote its Construction Management programme(s).

What is original/value of paper?
The study makes an important contribution to the construction management career promotion body of knowledge.
Keywords: Career, Construction Management, Registration
1. INTRODUCTION

The decision to pursue a specific academic programme in higher education is influenced by multiple interconnected factors, ranging from personal aspirations and societal perceptions to economic prospects. In today's academically competitive and market-driven landscape, the process of selection in higher education has taken on heightened significance.

Research conducted within the Australian higher education system has indicated that student enrolment decisions are largely influenced by familial backgrounds, demographic factors, and transitions between various educational settings [1].

Therefore, for universities to effectively attract students, it is imperative that institutional enrolment management gains a deeper comprehension of the determinants influencing student decisions. Accordingly, they should refine their recruitment strategies and organisational marketing practices to enhance the likelihood of students choosing their institution as their preferred place of study [2].

Given the strategic importance of the construction sector to South Africa's growth and the crucial role that universities play in shaping the industry's future, a deeper understanding of factors influencing student registration for CM programmes is essential. This study aims to unravel the motivations, deterrents, and patterns associated with student registrations for the BSc CM programmes at the NMU.

2. THE REVIEW OF THE RELATED LITERATURE

Construction is a rapidly growing industry, and the global volume of construction is predicted to increase 85% ($15.5 trillion USA) by 2030 [3]. As the volume of construction work grows and numerous professionals exit the sector due to retirement, the evident necessity is not just to replace, but to expand the construction workforce.

For a CM programme to generate competent graduates, it is essential to first draw students in, and subsequently ensure their continued participation in construction and the broad built environment [4].

2.1 Factors influencing students' university choices

Over the last thirty years, the decision-making process in higher education has emerged as a noteworthy research focus, particularly with the increasing commercialisation of education [5]. The substantial investment in research concerning educational choices stems from the belief that by comprehending the driving factors behind these decisions, institutions can more effectively target market segments, thereby enhancing enrolments and subsequently increasing institutional revenues in the increasingly competitive higher education environment [5].

A PhD study identified the importance of social media in terms of attracting new students. The findings indicate that 69.5% of students spent between 1 and 3 hours on social media with 15.5% of students spending more than 4 hours a day on social media. The recommendations included that Facebook was the most popular social media platform, and universities should ensure that their Facebook pages either directly provide the essential information or contain links directing potential students to the required details [6].

Researchers conducted a study aimed to identify factors from a student perspective resulting in registration at a particular university in South Africa. From a total of 17 factors that were identified to influence students' decision-making in terms of selecting a university, the top five were as follows: the quality of teaching (1); availability of financial aid (2); ease of securing employment during and post-study (3); globally recognised qualifications (4), and sports and recreational programmes (5) [7].

2.2 Factors Influencing female students' choices
The perception of the construction sector is often associated with being dirty, exhibiting strong masculine tendencies, having a hostile environment, being expensive, quality non-conformances, and physically demanding activities [8]. Numerous academic studies have highlighted employers' challenges in attracting women to professional roles within the construction sector. Scholarly investigations in this domain have concentrated on enticing women to pursue academic majors in architecture, engineering, and construction (AEC) and on ensuring their sustained presence in the construction field post-graduation [9]. The limited number of women who opt for a qualification in construction often encounter an educational journey deeply influenced by a predominantly masculine ethos, marked by specific beliefs, actions, and presumptions [10].

A research initiative at the Ara Institute of Canterbury, New Zealand, entailed surveying female AEC programme students. One of the salient recommendations emerging from this research was the introduction of female professionals as guest speakers in secondary educational institutions to endorse construction-related careers for women. The study further underscored career advisers' pivotal role in directing students towards AEC programmes. Moreover, the findings advocated for more interactive university day open-day experiences and emphasised the need for enhanced female representation in the construction sector to counter prevailing biases [11].

2.3 Factors Influencing the selection of CM as a major

The research paper from Purdue University, titled ‘Construction Management Technology Students Choice of Major’ provides interesting insights. Notably, most respondents were male (79%), with 18% female and 3% identifying as other. The predominant age range was between 18 and 22 years. The racial composition was predominantly White (83%), with underrepresented minority groups constituting 9%. 26% of the respondents were first-generation college students, and among underrepresented groups, the number of first-generation college students increased to 39%. The study highlighted the gender and racial disparities within the student population in CM, with a significant majority being male and white. Females exhibited higher levels of motivation and confidence in their construction education-related abilities than their male counterparts. In addition, self-efficacy played a crucial role in students' persistence in CM programmes [12].

During a detailed study led by Melissa Thevenin and Dr. Jonathan Elliott from Colorado State University [13], the influence of mentors and role models on students in CM was examined. The research, involving 587 students from three universities, aimed to uncover the relationship between influential figures and students' attraction to CM careers, a notably male-dominated field. The study highlighted the significant challenges women face in such sectors and emphasised the vital role of self-efficacy and motivation in shaping career paths. It also underscored the importance of mentors and role models in developing self-efficacy beliefs, especially for women in non-traditional fields [13].

Utilising a tailored quantitative survey, the researchers explored the correlations between influential individuals and students' construction education self-efficacy (CESE) and motivation (CEM), focusing on identifying gender-based disparities. The survey results from 828 students yielded 587 analysable responses, revealing a demographic of 11.0% females and 89.0% males. About 50.3% reported having a mentor, and 73.6% acknowledged a role model [13]. The findings demonstrated a significant positive correlation between having influential figures and students' self-efficacy and motivation in construction education for both genders. However, the correlation with self-efficacy was not statistically significant for females. The study concluded that the presence of mentors, role models, self-efficacy, and motivation are key determinants of career choices and academic success in construction education. The insights from this research contribute to a deeper understanding of the impact of influential figures in construction education and suggest avenues for further exploration [13].

3. RESEARCH METHOD
Due to the nature and extent of the data required, the quantitative method was adopted, which entailed the use of a self-administered questionnaire consisting of eleven questions, ten of which were closed-ended, and one open-ended. Five of the closed-ended questions pertained to the study and included a further five sub-questions. The remaining five closed-ended questions were demographically related and included a further sub-question.

The sample frame included two first-year CM cohorts over two academic years during first-year orientation at the commencement of the respective academic years. A further cohort consisted of second-year students from an academic year.

A total of 48 responses were received, and the data was captured and analysed utilising Microsoft Excel to produce descriptive statistics in the form of frequencies.

4. Research Findings

Table 1 presents the gender and nationality of the respondents, and form of funding. Notably, females constitute 46.8% and males 53.2% of the respondents, which bodes well in transforming the construction industry, which industry features limited female representativity. South Africans (83.0%) predominate in terms of the nationality of students; international students only constituting 17.0% of the respondents. Only 51.0% of students are funded, 34.0% by NSFAS, and 17.0% by others. Approximately half (49.0%) are not funded.

The mean age, which is not presented in Table 1, is 20 years for females and 21 for males.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Percentage (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Total</td>
</tr>
<tr>
<td>Gender</td>
<td>46.8</td>
<td>53.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Nationality:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South African</td>
<td>38.3</td>
<td>44.7</td>
<td>83.0</td>
</tr>
<tr>
<td>International</td>
<td>8.5</td>
<td>8.5</td>
<td>17.0</td>
</tr>
<tr>
<td>Total</td>
<td>46.8</td>
<td>53.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Form of funding:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funded by NSFAS</td>
<td>36.3</td>
<td>32.0</td>
<td>34.0</td>
</tr>
<tr>
<td>Funded (Other)</td>
<td>18.2</td>
<td>16.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Not funded</td>
<td>45.5</td>
<td>52.0</td>
<td>49.0</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2 indicates the respondents’ source of awareness of the CM programme.
It is notable that no source was identified by ≥ 50.0% of respondents. The internet was the only source which was identified by a ≥ 33.3% (a third) of respondents (37.8%). Career guidance and family were each identified by ≥ 20.0% (a fifth) of respondents (22.2%). Thereafter, friends and professional association were each identified by 8.9% of respondents. Career fair was not identified by any respondents.

<table>
<thead>
<tr>
<th>Source</th>
<th>Yes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet</td>
<td>37.8</td>
</tr>
<tr>
<td>Career guidance</td>
<td>22.2</td>
</tr>
<tr>
<td>Family</td>
<td>22.2</td>
</tr>
<tr>
<td>Friends</td>
<td>8.9</td>
</tr>
<tr>
<td>Professional association</td>
<td>8.9</td>
</tr>
<tr>
<td>Career fair</td>
<td>0.0</td>
</tr>
</tbody>
</table>

33.3% of respondents' family work in the built environment, and 66.7% of respondents' family do not. Table 3 indicates the capacity in which the former do so.

Civil Engineer (37.5%) predominates, followed by Construction Manager (25.0%), Quantity Surveyor (12.5%), and then CAD Technician, Interior Designer, Plant Operator, and Town Planner, which were each identified by 6.3% of respondents.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Yes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Engineer</td>
<td>37.5</td>
</tr>
<tr>
<td>Construction Manager</td>
<td>25.0</td>
</tr>
<tr>
<td>Quantity Surveyor</td>
<td>12.5</td>
</tr>
<tr>
<td>CAD Technician</td>
<td>6.3</td>
</tr>
<tr>
<td>Interior Designer</td>
<td>6.3</td>
</tr>
<tr>
<td>Plant Operator</td>
<td>6.3</td>
</tr>
<tr>
<td>Town Planner</td>
<td>6.3</td>
</tr>
</tbody>
</table>

The majority (66.7%) of respondents considered another or other programmes, and 33.3% did not. Table 4 indicates the other programmes respondents considered. A notable 15 other programmes were identified by one or more of 32 (66.7%) of the respondents. BSc Construction Economics (34.2%) predominates, followed by Civil Engineering (23.7%), which are ‘close’ sister disciplines of CM. Except Architecture (7.9%), and Mechanical Engineering (5.3%), each of the remaining 11 disciplines were identified by 2.6% of the respondents.
Table 4 Other programmes considered by respondents.

<table>
<thead>
<tr>
<th>No.</th>
<th>Source</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>1</td>
<td>BSc Construction Economics</td>
<td>7</td>
<td>14.6</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Civil Engineering</td>
<td>2</td>
<td>4.2</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Architecture</td>
<td>2</td>
<td>4.2</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Mechanical Engineering</td>
<td>1</td>
<td>2.1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>BSc Geosciences</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>BSc Mining Engineering</td>
<td>1</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>BSc Property Development</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Diploma: Building</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Education</td>
<td>1</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Industrial Engineering</td>
<td>1</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>Law LLB</td>
<td>1</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Medicine MBChB</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>Nursing</td>
<td>1</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>Statistics</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>Town Planning</td>
<td>1</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>18</td>
<td>37.5</td>
<td>20</td>
</tr>
</tbody>
</table>

Of the 32 (66.7%) of students that considered other programmes, 30 / 32 (93.8%) applied to another university. Table 5 presents an overview of the respondents who applied to another university. In summary, there is not a major disparity between female and male.

Table 5 Respondents who applied to another university.

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>South African</td>
<td>12</td>
<td>26.7</td>
<td>5</td>
</tr>
<tr>
<td>International</td>
<td>2</td>
<td>4.4</td>
<td>2</td>
</tr>
</tbody>
</table>

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
A total of 14 male (56.0%) students applied to eight universities, NMU (24.0%) included, and a total of 11 (44.0%) female students applied to seven universities, NMU (16.0%) included.

Table 6 indicates the factors that resulted in respondents finally registering for CM at the NMU. Changed my mind (44.4%) predominates, followed by First choice (Programme) (27.8%), and First choice (University) (22.2%). It is notable that First choice (Programme) was identified by more respondents, albeit it marginally so, than First choice (University).

Table 7 indicates the extent to which factors contributed to respondents registering for the CM programme. Respondents were presented ten factors and an ‘other’ option.

In terms of the total responses, ‘wish to pursue a career in CM’ (59.6%) predominates, followed by ‘wish to pursue a career in the built environment’ (42.6%), ‘wish to pursue a career in construction’ (34.0%), ‘vocational qualification’ (25.5%), ‘business qualification’ (23.4%), and ‘job opportunities’ (10.6%). A further three factors were identified by between 2.1% to 6.4% of respondents, and no respondents identified ‘other’.

A notable difference is in the form of 68.0% (males) relative to ‘wish to pursue a career in CM’ compared to 50.0% (females).
Table 7 Extent to which factors contributed to respondents registering for the CM programme.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Wish to pursue a career in CM</td>
<td>11</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>Wish to pursue a career in the built environment</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Wish to pursue a career in construction</td>
<td>9</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Vocational qualification</td>
<td>5</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Business qualification</td>
<td>5</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Job opportunities</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Potential income</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Manage the family business</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Variety of subjects (Programme)</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Types of subjects (Programme)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>25</td>
<td>47</td>
</tr>
</tbody>
</table>

Table 8 indicates the respondents’ medium to long term desired career in terms of the built environment. Respondents were presented five careers and an ‘other’ option.

In terms of the total responses, Construction Project Management (45.7%), and Contracting (CM) (32.6%) predominate, followed by CM consulting (13.0%). A further three factors were identified by between 0.0% to 4.3% of respondents.

A notable difference is in the form of 30.4% (males) relative to Construction Project Management compared to 15.2% (females).

Table 8. Respondents' medium to long term desired career in terms of the built environment.

<table>
<thead>
<tr>
<th>Career</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Construction Project Management</td>
<td>7</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>Contracting (CM)</td>
<td>7</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>CM consulting</td>
<td>5</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Research &amp; Development</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Materials manufacturing / Supply</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
5. CONCLUSIONS
The diverse sources of respondents' awareness of the CM programme suggest that there is unexploited potential to intensify awareness through channels such as the Internet, career guidance, professional associations, and career fairs.

Furthermore, the CM programme faces competition from other built environment programmes and those leading to non-built environment careers. However, the notable percentage responses relative to BSc Construction Economics and Civil Engineering pinpoint them as the principal competitor programmes.

It is also evident that potential students tend to apply to various universities, suggesting a non-exclusive preference for any single institution. The decisive factors leading to registrations at NMU indicate that a mix of the programme's appeal and the university's reputation play a significant role in students' final choices.

The myriad factors contributing to registrations imply that the CM programme holds inherent appeal with its vocational and business qualifications and potential job opportunities. Nevertheless, the predominant desire to pursue a career in CM or the broader built environment underscores the challenge posed by competitive programmes.

Furthermore, the prevailing career aspirations in Construction Project Management and contracting affirm the enduring recognition of CM programmes for their foundational purpose developed in the 1960s – managing the business of construction and projects. However, the emergence of construction project management in the 1980s and the subsequent evolution of CM programmes have positioned them as the foundational pathway for the discipline.

In conclusion, while the CM at NMU is recognised and valued, it is imperative to explore enhanced promotional strategies, acknowledge the competitive academic landscape, and continue to adapt the programme to align with the evolving demands and aspirations of potential students in the field.

6. RECOMMENDATIONS
A multi-pronged approach is required in terms of promoting CM programmes. Furthermore, a range of stakeholders need to contribute, which includes employer associations, government departments, primary and secondary schools, professional associations, statutory councils, and tertiary institutions. However, a prerequisite in many cases is the development and provision of suitable material for, inter alia: the internet, including social media; career fairs, career guidance, and distribution.

CM should differentiate itself from other built environment programmes and elucidate on the multiple career paths that graduates can avail themselves of.

Given that students consider other programmes, and apply to a range of universities, the achievements of CM graduates and their career paths should be used by a university to promote its CM programme(s).
The inherent aspects of CM programmes, namely being a vocational qualification, a business qualification, and the potential job opportunities or career paths should be emphasised during career promotion interventions.

7. REFERENCES


Adoption of Engineered Wood Products in the Building Construction Industry – A Conceptual Model

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ABSTRACT
Purpose of this paper
Engineered wood has emerged as a viable alternative to concrete and steel in the construction industry due to its low-carbon footprint and technical performance as a structural material. However, the adoption of this technology in the industry is still quite low. This study explores the barriers and drivers of adoption and develops a conceptual model for increased adoption of engineered wood products in the construction industry by combining elements of the diffusion of innovations theory and the theory of planned behaviour.

Design/methodology/approach
A critical literature review approach was employed to systematically analyse and synthesise existing literature to promote a nuanced understanding of the research topic.

Findings
The review revealed that path dependency, lack of awareness and experience, cost of engineered wood, restrictive building codes and negative perceptions of wood are some barriers to adoption. On the other hand, government policy and collaboration between the wood and construction industries have been proven to drive the adoption of engineered wood products. The technical performance of wood as a structural material, the reduction in construction times and its environmental benefits may also serve as potential drivers.

What is the original/value of paper. The conceptual model developed establishes a framework that researchers can utilise to examine the adoption of engineered wood in construction while also serving as a practical tool for advocates seeking to enhance the adoption process.

Keywords: Engineered wood products, Construction industry, Innovation diffusion, Adoption, South Africa.
1.0 INTRODUCTION

The construction industry is a vital component of the modern economy. On average, the industry contributes more than 10% to the world’s gross domestic product (GDP), employs over 100 million people globally and is expected to surpass 15 trillion dollars in value by 2030 (Osei et al., 2017; Morena and Amoah, 2021; Marsh et al., 2021). In South Africa, the industry added over 104 billion rands to the country’s GDP in 2019, according to a report by the Construction Industry Development Board (CIDB). Despite recent downturns in the construction industry, it continues to contribute significantly to the country’s economy. It is estimated that the construction industry employs over 1.4 million people across the country (Osunsanmi et al., 2018).

However, these benefits are offset by high energy consumption, waste production and greenhouse gas emissions associated with the industry (Xia et al., 2014). Hurmekoski et al. (2015) reported that the construction industry consumes more than half of all earth’s resources, including 15% of water and 40% of global energy output, while generating one-third of all waste production. Additionally, the industry is responsible for 30–45% of all carbon dioxide-related emissions contributing to global warming and climate change (Ahmed and Arocho, 2021; Zaman et al., 2022; Giorgio et al., 2022). In South Africa, cement production is responsible for 94% of the CO2 emissions from concrete, while reinforced concrete — the nation’s most common construction material — is responsible for almost 90% of the global warming potential attributed to buildings (van der Westhuysen and Wium, 2021).

As the construction industry comes under increasing scrutiny for the effect of its activities on the environment, many countries are moving toward green building techniques. Using wood as a structural element has emerged as a possible solution to mitigate the severe environmental impact of conventional construction materials and reduce the construction industry’s impact on global warming and climate change (Toppinen et al., 2019; Sikora et al., 2018). Research into the mechanical and structural properties of wood, combined with innovative experimentation, has resulted in the development of composite materials referred to as engineered wood products (EWPs) (Van Acker, 2021). The adoption of EWPs may reduce the environmental impact of the construction industry, and thus, the objectives of this study were to:

1. Identify the barriers to the adoption of EWPs.
2. Identify the drivers for the adoption of EWPs.
3. Develop a conceptual mode to promote the adoption of EWPs using the Diffusion of Innovations Theory (Rogers, 2010) and the Theory of Planned Behaviour (Ajzen, 1991).

The study commenced with a general background literature survey of EWPs. This was followed by a discussion regarding the methodology used to achieve objectives one and two. A systematic literature review was performed, and the results were summarised. This was followed by a discussion of the Diffusion of Innovations Theory and the Theory of Planned Behaviour. A conceptual model was proposed, and subsequently, conclusions were drawn.

2.0 LITERATURE REVIEW

Engineered wood products is a collective term used to refer to a category of wood products which are manufactured through the combination of wood elements such as lumber, veneers and strand materials bound together using adhesives to form a range of composite structures under high temperatures and/or pressure (Sikora et al., 2018; Penfield et al., 2022). There is a range of materials, such as laminated veneer lumber (LVL), laminated strand lumber (LSL), glue-laminated lumber (GLT, Glulam), and cross-laminated timber (CLT), that are considered as EWPs. Among these, Glulam and CLT are the most established and widely used wood products in the building construction industry, where they are also commonly referred to as mass timber/timber products (Ahmed and Arocho, 2021; Sikora et al., 2018).

EWPs have several advantages over other building materials regarding environmental benefits,
Structural performance, economic considerations, and construction-related advantages. Environmental benefits of EWPs originate mainly from the fact that they are made of wood materials, and several studies have shown that wood has superior environmental performance compared to concrete and steel (Espinoza et al., 2016a; Perković et al., 2021). Trees serve as a carbon store as they develop; when they die or are burned, carbon is released back into the atmosphere. However, utilising wood in construction maximises trees’ carbon sequestration properties (Evison et al., 2018). Additionally, when wood buildings reach their end-of-life, they can be demolished and recycled into other products, unlike alternatives like concrete (Perković et al., 2021).

Structurally, the high strength-to-weight ratio of wood makes it possible to build lighter structures with comparable structural capabilities as concrete and steel (Mallo and Espinoza, 2014). This is an advantageous solution in areas with difficult terrains and poor-quality soil where building with heavier materials would be more difficult, as well as in multi-storey building projects (Perković et al., 2021). Wood products like CLT are also advantageous in earthquake-prone areas as the material’s lightness and flexibility allow the building to withstand seismic forces much better than concrete structures (Mallo and Espinoza, 2014).

Furthermore, theoretical and practical studies comparing the cost of building with engineered wood products as opposed to other construction materials have revealed lower costs associated with building with wood products (Evison et al., 2018). A study on the costs of replacing the steel and concrete frames with wood products on a 6–storey apartment in British Columbia concluded that building with wood would have been 12% cheaper (Kremer and Symmons, 2016). Another study on wood-based constructions in Australia revealed lower construction costs, ranging from 2.2% for an 8–storey apartment to 13.9% for a 2–storey aged-care facility, compared to alternatives (Evison et al., 2018).

These cost savings have been attributed to reduced project time and project labour costs associated with off-site manufacturing (prefabrication) followed by the high speed of assembly of structures on-site (Mallo and Espinoza, 2014; Kremer and Symmons, 2016; Franzini et al., 2018). An assessment of wood-based building projects in the United Kingdom revealed savings in the project’s overall cost due to a 17–week reduction in project time despite the higher cost of CLT compared to concrete. In South Africa, a conceptual design study to examine the cost of developing a multi-storey structure utilising engineered wood instead of reinforced concrete revealed that wood-based buildings can be finished in half the time of reinforced concrete buildings while achieving better rates of return (van der Westhuizen and Wium, 2021).

Using EWPs in building projects also provides flexibility in construction that non-wood projects cannot provide. Architects interviewed as part of a study on the outlook of CLT in the United States revealed that wood products like CLT allow for various unique features (Mallo and Espinoza, 2014). Besides, wood-based buildings can be easily repaired during and after construction compared to concrete-frame buildings (Franzini et al., 2018). Furthermore, wood products are aesthetically pleasing and have been linked to reduced stress levels and improved residents’ quality of life and well-being (Xia et al., 2014; Hurmekoski et al., 2015).

However, despite the advantages of EWP in construction, the adoption of this innovation in the construction industry is low (Evison et al., 2018). As the industry with one of the highest contributions to global warming, the construction industry is pressured to commit to more low-carbon solutions (Jussila et al., 2022; Zaman et al., 2022). According to van der Westhuizen and Wium (2021), interest in the potential uses of EWPs in building construction is rising amongst construction professionals in South Africa. This study aims to probe the barriers and enablers of adopting EWPs in the construction industry. Additionally, the study will contribute to measures to improve the uptake of EWPs through the development of a conceptual model for adoption.

3.0 RESEARCH METHODOLOGY

The study adopted a systematic literature review to explore the drivers and barriers to adopting engineered wood products in the construction industry. An interpretivist philosophy was used to interpret the existing literature, and inductive reasoning was used to develop theory (Khan, 2014). According to Webster and Watson (2002), reviewing relevant literature on a subject provides a strong foundation for advancing knowledge of a topic. It makes building theories that apply to both research and practice easier. A literature review may also
be valuable when mapping the developments in a research area and creating a conceptual model or new theory (Snyder, 2019).

This study began with identifying reputable electronic research databases to search for past studies. Scopus and Web of Science have emerged as the most reputable scientific literature sources (Chadegani et al., 2013). A desktop search of relevant terms followed, and citation records for the results produced were retrieved. The initial search terms include engineered wood products, construction, and adoption. Records were initially screened to identify and purge duplicates, and then the titles and abstracts of the remaining articles were screened to ascertain their relevance to the research topic.

The full texts of articles that demonstrated clear relevance to the research topic and aligned with this study’s objectives were retrieved. In addition to the selected articles, the references cited within them were reviewed to identify potential additional sources. Articles that met the criteria based on their titles were retrieved using Google Scholar and reviewed to determine their suitability for inclusion in the study. It should be noted that the researchers did not intend for the search terms to be exhaustive or conclusive; rather, they were merely employed to provide access to enough relevant studies.

A total of 446 papers were identified from the combination of the initial literature search and the reference search. After duplicates were identified and removed, 430 records remained. Screening of titles and abstracts based on study relevance resulted in the selection of 56 articles. Based on the availability and review of the full text, 41 articles were eventually selected for this study.

4.0 RESULTS AND DISCUSSION

4.1 Barriers to Adoption

The nature of the construction industry to be slow to change and resistant to innovations is regarded as one of the most significant barriers to the adoption of EWPs (Hemström et al., 2011). The construction industry is typically regarded as more path-reliant, fragmented, and risk-averse than many other economic sectors. Therefore, when new products are introduced into the construction industry, there is usually resistance, little consumer knowledge, and a lot of market uncertainty (Hurmekoski et al., 2015; Markström et al., 2018). This “industry inertia”, as coined by O’Connor et al. (2004), can be attributed to the industry’s path dependency a preference for using long-standing and familiar products like concrete and steel (Viholainen et al., 2021).

Besides, professionals in the construction industry have developed expertise in using conventional building materials and are generally unwilling to adopt new materials and processes (Jussila et al., 2022; Gosselin et al., 2017). Moreover, company policies may prefer concrete or steel, a situation that individual actors cannot challenge or change (Toppinen et al., 2019; Roos et al., 2010). Jones et al. (2016) revealed that construction firms with a sizable market share and extensive expertise using concrete often fight against innovation that could harm their bottom lines. They are reluctant to consider options that might jeopardise their short-term financial success and aggressively fund concrete and steel research and interests (Pei et al., 2016).

A related challenge is the question of who selects the construction material. Professionals, including architects, engineers, construction workers, contractors, and financiers, are employed in the construction business and involved in every element of decision-making (Jones et al., 2016; Penfield et al., 2022). Furthermore, these stakeholders collaborate on a short-term basis and are more interested in obtaining immediate profit, hence sticking to established practices rather than risk new procedures (Jones et al., 2016). According to Jones et al. (2016) and Penfield et al. (2022), construction stakeholders seldom accept responsibility for incidents occurring in the industry due to the industry’s highly fragmented nature and numerous actors with diverse interests. Hence, path dependence and traditional construction procedures serve as low-risk solutions to ensure collaboration (Hurmekoski et al., 2015).

Another barrier to using wood products in construction is the lack of awareness of the benefits of EWPs as a structural material (Ahmed and Arocho, 2021). Studies by Roos et al. (2010), Xia et al. (2014), Mallo and
Espinoza (2015) and Markström et al. (2018) on architects, engineers, contractors, and other construction professionals have revealed low levels of awareness about EWPs among these key stakeholder groups. According to Kremer and Symmons (2016), there is a common ignorance of emissions and energy use as they relate to the use of wood in construction, and some stakeholders are unaware of the ability of wood-based construction to help reduce greenhouse gas emissions and global warming. Ahmed and Arocho (2021) revealed that many contractors and subcontractors have limited experience working with wood products, limiting adoption.

A study of civil servants and local government actors responsible for approving construction plans revealed a dearth of knowledge among the regulators about the technical aspects of wood-based building construction (Franzini et al., 2018). One reason for the limitation in knowledge was the relative difficulty in accessing project information. However, a lack of incentivisation to learn about new products such as EWPs was also revealed (Franzini et al., 2018). This mirrors claims by Roos et al. (2010) that some architects and engineers lack the motivation to be more informed about EWPs because they do not think it would significantly impact their careers. In contrast, architects and structural engineers surveyed by Penfield et al. (2022) expressed confidence in their ability to work with EWPs despite their limited knowledge and product experience.

For stakeholders who have some awareness of wood-based projects, material property limitations limit the rate of adoption of EWPs. One area is in sound performance, as wood structures tend to be noisy, making acoustics management and sound insulation systems difficult to implement (Hemström et al., 2011; Franzini et al., 2018; Giorgio et al., 2022). Additionally, the presence of moisture in wood products negatively impacts their durability. In areas with high rainfall, it is difficult to completely prevent moisture from seeping into wood structures, leading to the prevalence of mould, the delamination of panels and poor structural stability (Roos et al., 2010; Ahmed and Arocho, 2021). Furthermore, termites can damage wood panels if they become infested, which may undermine the strength and durability of the structure and increase maintenance costs (Xia et al., 2014).

Cost-related challenges also inhibit adoption (Ahmed and Arocho, 2021; Espinoza et al., 2016b). CLT, LVL and other common wood products are expensive (Espinoza et al., 2016a; Evison et al., 2018). Moreover, facilities that produce EWPs are in short supply worldwide, so project teams often import the product at premium prices and with high transportation costs (Ahmed and Arocho, 2021). According to Markström et al. (2018), project construction costs are considered significant when the choice of construction material is made; hence, the high cost of EWPs may hinder their selection as the preferred construction material. However, there is growing evidence that the high cost of EWPs is offset by the savings made through reduced project time and labour costs (Kremer and Symmons, 2016). Still, additional costs like insurance costs and extra fire protection systems related to fears about the fire performance of wood or seismic reinforcements for buildings in earthquake-prone regions contribute significantly to the overall cost of construction and the long-term costs of building maintenance (Penfield et al., 2022; Gosselin et al., 2017). Construction regulations in the form of restrictive building codes also limit the adoption of EWPs in construction (O’Connor et al., 2004; Ahmed and Arocho, 2021; Mallo and Espinoza, 2014). According to Evison et al. (2018), in many countries, standards bodies have not kept up with improvements in wood technology and are not prepared to adopt EWPs. As such, current building codes limit the use of wood products in construction, especially in larger structures (Schmidt and Griffin, 2013). Inadequate government policies have been blamed for a lack of evolution in building codes. According to Sikora et al. (2018), wood-based construction in China has been severely limited due to the lack of a policy supporting the use of wood products in construction.

Ultimately, the negative perception of wood as a structural material may be the most significant barrier to the adoption of EWPs in the construction industry. Several studies have revealed that consumers perceive concrete and steel as strong, durable and dependable materials for load-bearing and other structural purposes in construction as opposed to wood (Mallo and Espinoza, 2014; Kremer and Symmons, 2016; Giorgio et al., 2022; Viholainen et al., 2021). According to Giorgio et al. (2022), users also perceive wood products to have a
short lifespan and as generally unsuitable for multi-storey building construction. Xia et al. (2014) reported that some users consider wood a bygone-era construction product. Meanwhile, Hemström et al. (2011) revealed that some architects and engineers consider working with wood products complicated and challenging. Another persistent negative perception is that wood products are highly combustible (Gold and Rubik, 2009; Xia et al., 2014). Both users and construction professionals perceive that EWPs have weak fire resistance since they are made from wood, despite studies indicating that they have better fire performance (Schmidt and Griffin, 2013; Evison et al., 2018; Mallo and Espinoza, 2014; Kremer and Symmons, 2016).

4.2 Drivers for Adoption

Government policy and support for the wood industry have been proven to drive the adoption of EWPs (Kremer and Symmons, 2016; Jussila et al., 2022). Franzini et al. (2018) reported that the introduction of the Timber Innovation Act in the United States spurred the recent construction of several multi-storey wood buildings. Similarly, Giorgio et al. (2022) revealed that changes to building codes have increased wood-based buildings in Canada. Franzini et al. (2018) linked the rise in wood-based buildings in Finland to major legislative changes and the review of building codes. In Sweden, the government sponsored developing several wood-framed multi-storey structures (Hemström et al., 2011).

While government policy can certainly drive the adoption of EWPs, experience with wood products will increase the confidence that architects, structural engineers, and other decision-makers in the construction industry have in EWPs. Hemström et al. (2011) reported that architects with prior experience using wood products in construction were highly inclined to use it again. Bysheim and Nyrud (2009) also indicated that architects with experience in wood-based construction are more inclined to view wood favourably. The study suggested that by enhancing the experience of construction professionals, uncertainty in the construction process can be minimised (Bysheim and Nyrud, 2009).

Education and training can improve the knowledge and awareness of construction professionals and reduce the negative perceptions of wood as a structural material (Hemström et al., 2011; Kremer and Symmons, 2016). Increasing awareness is also a good first step in driving adoption. When people are informed about an innovation, they are more likely to adopt it and spread it to others (Penfield et al., 2022). In a survey of construction professionals, Schmidt and Griffin (2013) found that respondents with more information about CLT were more willing to consider it as an alternative to concrete and steel than those with less knowledge.

Collaborative efforts between the wood and construction industries may also drive adoption (Toppinen et al., 2019). In Finland, the collaboration between wood and construction companies has enhanced the credibility of wood as a structural material and resolved technical issues that construction stakeholders highlighted (Hurmekoski et al., 2015). Besides, collaboration may increase awareness about the benefits of wood in construction (Toppinen et al., 2019). However, this may work better in areas with a culture of using wood in construction (Hurmekoski et al., 2015). Hurmekoski et al. (2015) found that the market proliferation of wood has so far occurred in countries where wood has a sizable market share, and the government and other interest groups have been encouraging the use of wood because of their dependence on the industry and its effects on the economy.

Wood’s strength-to-weight ratio makes it a more viable option for multi-storey building construction than concrete and steel and a potential alternative for areas with poor soil-bearing capacity (Ahmed and Arocho, 2021; Gosselin et al., 2017). Architects are also drawn to wood’s design flexibility, and its durability is a significant advantage for stakeholders and consumers aware of its properties (Ahmed and Arocho, 2021; Brock, 2010). The ability to prefabricate wood elements away from the construction site to reduce project time may also drive the adoption of EWPs, although time may not be a significant driver unless it is tied to a reduction in construction costs (Gold and Rubik, 2009; Espinoza et al., 2016b; Giorgio et al., 2022; Franzini et al., 2018).

Society’s recognition of the environmental benefits of wood may also drive the adoption of EWPs (Evison et al., 2018; Mallo and Espinoza, 2014; Kremer and Symmons, 2016).
et al., 2018). Markström et al. (2018) reported that the environmental benefit of wood was one of the factors that drove the construction of multi-storey wood buildings in Sweden. Similarly, architects in a study by Penfield et al. (2022) motivated their transition to using wood as construction material by referring to its environmental benefits. For governments and communities with environmental sustainability goals, increased EWP use in the construction industry may help these bodies meet their goals for climate action or sustainable cities and communities.

For many proponents of EWP in construction, users will serve as a significant driver for adopting EWPs in the construction industry (Franzini et al., 2018). User demand is expected to be powered by the aesthetics of wood in building construction, increasing awareness of the environmental benefits of wood and the increasing desire by users to be carbon neutral (Giorgio et al., 2022). Additionally, wood is associated with favourable trends such as comfort, ecological character, stress reduction, comfortable ambience, psychological wellness, and improvement in quality of life (Xia et al., 2014; Hurmekoski et al., 2015; Gosselin et al., 2017).

5.0 CONCEPTUAL MODEL FOR THE ADOPTION OF EWP
One of the aims of this study is to present a conceptual model for the adoption of EWPs by the construction industry. To develop a model, a review of the theoretical frameworks that previous studies have utilised to study the adoption of EWPs was undertaken. The two frameworks used were the diffusion of innovations theory and the theory of planned behaviour.

5.1 The Diffusion of Innovations Theory
The diffusion of innovation theory (DOI) describes the process by which new goods and services initially spread through a population until they are eventually adopted (Dearing and Cox, 2018). DOI considers diffusion as a special kind of communication process in which the innovation serves as the communication’s content. Innovations are unfamiliar to the population they are introduced to, which adds a level of ambiguity to the communication. The purpose of the theory is to explain how to get past this uncertainty and make sure that the information spreads throughout the population (Rogers, 2010). When introducing an innovation to a new population, DOI may provide some guidance as to what factors may affect the spread and adoption of the innovation (Hurmekoski et al., 2015; Markström et al., 2018).

According to Rogers (2010), the process of innovation diffusion begins with the awareness of the innovation. Subsequently, individuals form their opinions about the innovation and may then decide to adopt or reject the product. Some of the drivers of the innovation diffusion process are collectively referred to as the perceived innovation attributes (Rogers, 2010). They describe five properties — relative advantage, compatibility, complexity, trialability and observability — which present an innovation as a better option to potential users compared to its alternatives (Ben Hamadi and Fournès, 2023). Diffusion and adoption studies generally use the perceived attributes of innovation to explain innovation diffusion. However, the type of innovation-decision, the communication channels used, the nature of the social system and the effects of change agents are also related factors that impact the rate of diffusion of innovations (Rogers, 2010).

5.2 The Theory of Planned Behaviour
The theory of planned behaviour (TPB) is a theoretical framework to explain the likelihood of individuals developing or adopting a specific behaviour (Markström et al., 2018). The theory claims that personal attitudes, subjective norms and perceived behavioural control influence an individual’s intention to adopt a specific behaviour (Franzini et al., 2018). The theory helps to relate intention with behaviour and is one of the various hypotheses that attempt to explain the decision-making process (Bysheim and Nyrud, 2009). Attitude describes whether an individual feels negatively or positively towards the planned behaviour. On the other hand, subjective
norms refer to external pressures from the individual’s social group to engage in a particular behaviour.

According to TPB, intentions to engage in the activity grow when they have a positive attitude towards the behaviour and the aggregated subjective norm shifts in favour of performing the behaviour (Ajzen, 1991). Finally, the individual’s perception of the ease or difficulty of performing the required behaviour is measured by perceived behavioural control. Individuals with higher confidence in their ability to perform an activity are likelier to do the activity than those who don’t. TPB posits positive attitudes and subjective norms towards behaviour that strongly influence perceived behavioural control. Simultaneously, all three variables also influence the intention to adopt a behaviour (Ajzen, 1991). TPB, however, acknowledges that many behaviours are at least somewhat dependent on other elements, including opportunity, time, money, talents, and other people’s cooperation.

5.3 Conceptual Model

The most critical part of the innovation-decision process is the decision to adopt or reject an innovation. Existing research primarily centres around the perceived attributes of innovation to understand the adoption decision (Rogers, 2010). However, Rogers (2010) contends that this approach often neglects other significant factors in the diffusion process. Furthermore, the perceived attributes of innovations are more influential in the persuasion stage of the innovation-decision process. On the other hand, by relating intention to behaviour, TPB offers a model for predicting adoption behaviour. This study, therefore, integrates DOI with TPB to develop a pathway towards an increased adoption rate, as shown in Figure 1 below.

![Figure 1: Proposed conceptual framework (produced by authors)](image)

As the behaviour that this model seeks to embrace, the adoption of engineered wood products serves as the model’s dependent variable. The intention to adopt has been excluded from the model because positive attitudes and subjective norms indicate a strong intention to adopt the behaviour. Besides, a strong intention to adopt a behaviour strongly predicts final behavioural adoption (Ajzen, 1991).

Attitude is used to measure how a person evaluates a behaviour. Attitudes are formed based on beliefs about the outcomes of engaging in that behaviour. To gauge their attitudes to wood-based construction, Bysheim and Nyrud (2009) evaluated participants’ perceptions of some properties of wood, including structural performance, fire performance, aesthetics, cost savings and environmental benefits. Similarly, participants’
perceptions of wood based on aesthetics, structural abilities, fire performance and costs were used by Roos et al. (2010) to measure attitudes. Wood properties, building code regulations, compatibility with current construction practices, and material availability are perceived innovation attributes (Hurmekoski et al., 2015). Based on relationships between these attributes and attitudes suggested by Bysheim and Nyrud (2009), Roos et al. (2010), and Markström et al. (2018), this study hypothesises that the perceived innovation attributes of EWPs may directly influence the attitudes of individuals.

Subjective norms capture the perceived influence exerted by social pressures to engage in or abstain from a particular behaviour (Ajzen, 1991). The measurement of subjective norms is contingent upon an individual’s perceptions of influential persons and their evaluation of the behaviour. Furthermore, it considers whether these influences would express approval or disapproval toward the individual’s engagement in the behaviour. In analysing subjective norms that influence the intentions of architects to use wood in construction, Bysheim and Nyrud (2009) observed that respondents typically sought out the opinions of colleagues regarding new or unfamiliar products, suggesting that the opinions of colleagues play a big role in the intention to adopt a new behaviour. External influences like contractors and engineers also influenced the respondents’ choices. These influences are all part of the construction industry ecosystem (Hurmekoski et al., 2015). According to the theory of diffusion of innovations, diffusion occurs within a social system. Additionally, studies have shown that these industry actors influence the strength of the intention of individual members to adopt EWPs (Bysheim and Nyrud, 2009; Roos et al., 2010).

In a study of Swedish architects, Markström et al. (2018) measured the perceived behavioural control of participants by rating their influence over material selection and concluded that to increase the utilisation of EWPs, architects need to have more influence over the material selection process. Bysheim and Nyrud (2009) analysed participants’ influence over material selection to determine their perceived behavioural control. Similarly, Roos et al. (2010) observed that company policies on material selection typically favoured concrete, limiting the ability of participants to choose alternate options. Innovation decision centres on the decision to adopt or reject an innovation. According to Rogers (2010), innovation decisions may be limited to an individual’s choice, reached by a collective, decided by an authority figure or even involve a combination of the options. Therefore, the model proposes that the type of innovation decision-making influences perceived behavioural control.

Both communication channels and change agents are included in the model as moderating variables. Rogers (2010) presented the diffusion process as an information exchange network designed to minimise uncertainty about an innovation. Rogers (2010) highlighted three primary communication channels but admitted that the characteristics of prospective adopters heavily influence the selection of a specific communication channel. Change Agents, on the other hand, guide individuals in making decisions that align with the desired direction of a change agency. Typically, the change agent aims to promote the acceptance of new concepts while attempting to prevent the proliferation of undesirable innovations. Change agents may be proponents of EWP or conventional alternatives like concrete or steel; thus, the effect of these actors is considered a moderating factor in this model (Rogers, 2010).

6.0 CONCLUSION

The construction industry is widely recognised as a crucial component of the global economy. Acting as a catalyst for economic development, the industry brings together various resources, including equipment, materials, labour, and capital, to construct essential infrastructure and foster overall economic growth while employing millions of people along the way (Osei et al., 2017; Marsh et al., 2021; Morena and Amoah, 2021). With growing concerns over the environmental impact of construction activities, the construction industry is witnessing a shift towards green building practices in many countries. A key aspect of this transition involves reevaluating construction materials, as their efficiency directly influences energy consumption and greenhouse gas emissions.
Engineered wood products have emerged as an environmentally sustainable alternative to conventional building materials such as wood and steel. This study reviewed the barriers and enablers to adopting engineered wood products in the construction industry. Additionally, the study provides a conceptual framework for adopting EWPs in the construction industry by incorporating two common theoretical frameworks used to study the diffusion and adoption of innovations: the diffusion of innovations theory and the theory of planned behaviour.

The review revealed that the main barriers to adopting EWPs are the construction industry’s resistance to adopting innovations, lack of awareness and experience with wood amongst construction professionals and restrictive building regulations. On the other hand, government policy and legislation, collaboration between the wood and construction industries, and the environmental benefits of wood enable the adoption of EWPs.

Following Ajzen's theory of planned behaviour, the conceptual model proposes that adopting EWPs, which is the behaviour of interest, is influenced by attitude, subjective norms, and perceived behavioural control. In integrating the diffusion of innovations theory with the theory of planned behaviour, the model proposes that the perceived attributes of innovations, the nature of the social system and the type of innovation-decision influence the attitude, subjective norms, and perceived behavioural control, respectively. Communication channels and change agent efforts, the other two variables determining the adoption rate of innovations, act as moderating influences on adopting EWPs.

This paper contributes to the existing knowledge regarding adopting engineered wood products in the construction industry. While this paper is based on a comprehensive literature review, it is constrained by the inability to establish causal relationships among the variables. Further empirical investigations are necessary to establish causality and validate the framework proposed.

7.0 REFERENCES


The integration of BIM education into the South African Quantity Surveying curriculum

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ABSTRACT AND KEYWORDS

Purpose of this paper
The South African construction industry is currently adopting building information modeling (BIM), albeit its adoption is presently languishing behind that of other developed nations. It has become more popular in industrialized nations over the last decade, and South Africa is no exception. The objective of this study is to investigate the benefits that BIM education as part of the curriculum may provide to the Quantity Surveying profession, as well as the obstacles that institutions encounter when implementing BIM into the Quantity Surveying curriculum. The most effective processes and techniques Quantity Surveyors can harness by studying BIM and implementing it in their present operations will be given priority.

Design/methodology/approach
Questionnaire surveys and interviews were conducted among university lecturers, as well as quantity surveying and construction firms. The aim of the methodologies was to assess the value of adding BIM education to the quantity surveying curriculum, investigate the benefits and drawbacks of adopting BIM, and determine what the quantity surveying curriculum offers students' comprehension of BIM.

Findings
There are implications for integrating BIM learning into the quantity surveying curriculum, however, students are not acquiring adequate BIM exposure to be able to utilize the application as graduates entering the built environment. BIM competence is necessary and advantageous for quantity surveying graduates and its absence from the curriculum will have negative consequences on graduates entering the profession. This research found that there is a paucity of Building Information Modelling exposure offered to quantity surveying students in the quantity surveying curriculum and that there is a definite demand for BIM-competent graduate quantity surveyors in the built environment.

What is original/value of paper
BIM knowledge may be gradually introduced from the beginning of the quantity surveying curriculum to assist students to visualise certain components of the built environment and apply the software to accomplish university tasks more effectively. External practical workshops that have no bearing on the quantity surveying curriculum must be offered, highlighting the relationship between the profession and software applications.

KEYWORDS: South Africa, Building information modeling (BIM), Education, Curriculum, Quantity Surveying, Software Technology.
1. INTRODUCTION

Cost and timeliness are essential performance variables in addition to project quality. With the advent of parametric modeling, quantity surveyors have a pivotal function in facilitating these two essential components of the modeling process and assuring effective output from the inception (Boon, 2009). The quantity surveying profession in South Africa may soon integrate Building Information Modelling education into the curriculum, permitting students to compile comprehensive estimates and automated measurements. This will be done to expedite the conventional estimating process and to improve project document transcription, organization, and transmission. This study will examine the potential benefits of BIM education as part of the Quantity Surveying curriculum, as well as the complexities that institutions confront when implementing BIM into the Quantity Surveying curriculum.

BIM technology is becoming increasingly prominent among building industry professionals in developed countries (Ali, 2014). It is recognised for its substantial contributions to project success ( Chattopadhyay, 2001). The software allows for more efficient and productive working methods in certain domains and assists in the development of building cost estimates (Gokce, 2013). Consequently, the program may serve as an effective instrument in quantity surveying for estimating project costs ( Bandara, 2012). The objective of BIM is to provide a competitive edge in the estimating process ( Manning, 2014). By automating information documentation, BIM software is designed to minimize human errors and potentially generate a higher grade of data ( Gerrard, 2009). When properly implemented, BIM may enhance cost estimate accuracy, forecast the cost-effectiveness of design modifications more promptly, and provide a greater comprehension through improved visualization ( Chileshe, 2012). BIM users may also capitalize on its ability to obtain meta information for documentation ( Murphy, 2014).

In the construction industry, quantity surveying is an essential task as quantity surveyors are accountable for cost control and management throughout the project life cycle ( Standard, 2013). Quantity take-off and rate building are essential skills for a quantity surveying practitioner ( Ali, 2013). It entails estimating the most likely cost of a building project, which is dependent on a variety of parameters ( Ali, 2013). With escalating industry competitiveness and customer demands for value for money, precision, and timeliness, the quantity surveyor authorized to maintain estimating procedures may be pressured ( Keavney, 2013). BIM has become more frequently implemented in industrialized nations as construction projects get more intricate and quantity surveying firms are expected to thoroughly augment their capabilities to improve efficiency ( Papadonikolaki, 2016).

Quantity surveyors are being pushed to adapt to increase the value of their roles by integrating BIM into their practices ( Goedert, 2008). Quantity Surveyors have the potential to profit greatly from Building Information Modelling (BIM) since it allows professionals to apply the New Rules of Measurement, subsequently speeding up the estimating process ( Kulasekara, 2013). The relevance of Quantity Surveying as a profession grasping the full potential of everything that BIM has to offer is emphasized by recent advancements made in automated measurements and quantifications ( Kam, 2013). BIM is a revolutionary way of planning, constructing, and operating buildings, whilst BIM Education is the process of learning the essential information and abilities to produce BIM deliverables and meet their specific criteria ( Raphael, 2014). It comprises a range of ideas, apparatuses, and procedures that professionals in the industry must understand and apply ( Alufohai, 2012).

Given the considerable rise in BIM adoption in industrialized nations over the last decade, there is enough data to investigate the impact of the most used BIM capability-measurement characteristics in quantity surveying. According to a survey done by McGraw-Hill (2012) in North America, BIM is used by 67 percent of engineers, 70 percent of architects, and 74 percent of contractors. As per a survey performed by BEICC (2010) in Australia, BIM was utilized by 49 percent of architects, 75 percent of engineers, and 75 percent of contractors to simplify their modern routine. According to Hill (2012), nine out of ten BIM users in South Korea gained benefits from utilizing BIM, and by having favourable attitudes toward BIM ideals, they feel they gained more from sustained use. This raises the question of what possibilities BIM technology may offer quantity surveyors and, as a result, offers a foundation for determining whether BIM learning can be integrated into the South African quantity surveying program.

1.1 BIM Instruction and Quantity Surveying Education

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
The inquiry was prompted by a lack of scholarly material on BIM deployment and a deficit in BIM education in South Africa. As a result, much of the literature on the issue focuses on research conducted in other nations. Comprehensive research on the education required to become a quantity surveyor is necessary to adequately examine the ramifications of adding BIM education into the South African curriculum. Anderson (2012) defines education as “the wealth of knowledge acquired by an individual after studying specific subject matters or experiencing life lessons that provide understanding for something.” The demand for Quantity Surveyors is strong, according to Shafiei (2011), yet there are greater skill shortages than ever before. According to the Royal Institute of Chartered Surveyors (RICS), the number of qualified candidates for Quantity Surveying positions has dropped to its lowest level since 2008. In order to be completely prepared to work as a professional in the construction industry, as per Tsai (2014), quantity surveyors must have a thorough awareness of their obligations toward cost advising, cost planning, and contract administration. A graduate quantity surveyor must be as qualified as conceivable to enter the world of the fourth industrial revolution. According to Olanrewaju (2015), graduate quantity surveyors must have a solid understanding of their responsibility toward cost consulting, budget control, and tender documents in order to be competent as construction professionals. This involves the necessity for software that is expected by established firms to assist graduate quantity surveyors with work readiness, rendering it critical to consider the progressive incorporation of BIM education into the quantity surveying curriculum.

1.2 Implications of Curriculum Modification
The students who will be impacted by the modifications to the curriculum are the most crucial stakeholders in curriculum changes (Borkan, 2018). Gonzalo (2018) outlines the main concerns raised by students during a curriculum reform at Vanderbilt and suggests that curriculum reformers: convey the justification; respect students' fear; modify extracurricular leadership positions and create continued student-administrator involvement. The students must constantly be included at all stages of the development, implementation, and assessment of curriculum reform since they are the main stakeholders in the curriculum (Borkan, 2018). Changes to the curriculum should be the result of input from academics, policymakers, students, and the community for them to be beneficial (Borkan, 2018). It is necessary to think about new strategies that make use of the shared value idea to assist the construction industry in developing new strategies for boosting productivity and revenue by enhancing student and employee accomplishment levels (Bandara, 2012).

1.3 The Relevance of Software Programs in the South African Construction Industry
Every sector has experienced a rapid transformation as far as how operations are conducted, with significantly improved outputs. However, Ridell (2017) stated that software is an indispensable asset and investment for any construction company, contractor, or subcontractor in a field where everything hinges on the efficacy and reliability of humans. By utilizing software, a wide range of activities may be managed, tracked, and carried out very effectively. Smith (2014) asserts that many participants in the construction sector generally misconstrue the phrase "innovation." Gunderson (2009) defines construction innovation as "the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change". According to Kiprotich (2014), "the construction industry is ripe for disruption," but to put new ideas into practice, the sector must challenge the way individuals are already reasoning, working, and building. Although change is underway, many strategies that have been discussed for time on end do not emerge to be embraced on the level necessary to transform the sector as a whole.

1.4 Building Information Modeling
Building Information Modelling (BIM) was originally presented prior to the twenty-first century, and the desire for more comprehensive building information regarding intricate designs was the primary driver underpinning its development (Succar, 2010). BIM is widely utilized as an information technology approach for merging software tools (Tsai, 2014). According to Halvitigala (2010), BIM is a pre-determined sequence of tasks that consists of data.
assimilation, migration, and correlation to unit costs. The conventional approach for conducting these tasks comprises everything from taking off to compiling a preliminary bill of quantities (BEIIC, 2010). BIM-enabled estimating aids in limiting the activities of granular estimating by harmonizing processes (Alufohai, 2012). According to Odeyinka (2013), integrating BIM requires distinct education and capacities as opposed to utilizing the conventional method. Since estimates are not a function of the quantities generated automatically, using BIM does not invariably deliver an estimate (Abdirad, 2017). BIM data can be geometric or non-geometric, and it is expected to facilitate the efficient joint effort, enhanced data authenticity, erudite documentation, dispersed availability, and acquisition of building data (Boon, 2009). BIM is also expected to provide high-quality project results through the optimized quality preview, as well as interdisciplinary cooperation (Murphy, 2014). The world is constantly advancing, and the equipment employed in the construction sector is no exception to these technological advancements (Alufohai, 2012). This implies that companies in the construction sector must either change in order to keep their competitive edge or risk becoming obsolete and being supplanted by enterprises that are prepared to adopt these innovations (Boon, 2009). One of these innovations, known as BIM, is growing in importance as a tool for better information exchange and cooperation in the built environment (Abdirad, 2017).

1.5 The Connection Between Quantity Surveying and BIM

According to Liu (2014), the customary duty of the quantity surveyor may need to change as a direct consequence of BIM since BIM technologies are replacing some of the services provided by the profession. Therefore, it is essential to comprehend how the tasks and position of the quantity surveyor of the future will change as BIM procedures become more conventional and practical. Additionally, according to Kumanayake (2012), the attraction of the profession will be maintained by offering the appropriate quantity surveying services to fulfill the intrinsic and varied requirements of clients. The following are attributes that BIM offers quantity surveying firms:

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<th>Classifications</th>
<th>BIM Attributes</th>
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<tr>
<td>Rendering Data</td>
<td>Modelling, price regulation, quality control, estimation, and tendering.</td>
<td>(Halvitigala, 2010),</td>
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<td></td>
<td>Assessment of 5-dimensional economic feasibility.</td>
<td>(Nadeem, 2015),</td>
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<td>Data processing, graphical assessment</td>
<td>(Sher, 2014),</td>
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<td>3-dimensional representations of a bill of preparatory work</td>
<td>(Thurnell, 2015)</td>
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<td>Consistent Database</td>
<td>Take-off in perspective of supply and expense</td>
<td>(Sher, 2014),</td>
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<td></td>
<td>Administration of refurbishment expenditures after finalization</td>
<td>(Gokce, 2013),</td>
</tr>
<tr>
<td></td>
<td>Recognizing concept adjustments</td>
<td>(Piebankiewicz, 2015)</td>
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<tr>
<td>Integration of Data</td>
<td>Simulates models</td>
<td>(Sher, 2014),</td>
</tr>
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<td></td>
<td>Networking and metadata availability</td>
<td>(Nadeem, 2015)</td>
</tr>
</tbody>
</table>

Table 1 lists the benefits that BIM provides to the quantity surveying profession. Comprehension of the aforementioned characteristics will make quantity surveying graduates more resourceful in the built environment and more prepared to enter the fourth industrial revolution period.

1.6 BIM Adoption in South Africa

BIM has the capacity to strengthen industry competitiveness and increase engagement and revenue (Aiyetan, 2011). The significance of BIM on the South African construction sector, as well as the prospect for economic expansion,
must be recognized, as per (Aiyetan, 2011). Abdirad (2017) states that a competent BIM integration framework will aid the dutiable and export businesses to prosper. Construction, real estate services, and mining are three areas in South Africa where BIM may be utilised (Booyens, 2013). These subdivisions constitute nearly a quarter of South Africa's Gross Domestic Product, denoting that, amidst the premise that South Africa has not yet attained the key metrics of developed countries, BIM adoption would contribute to economic prosperity (Thurnell, 2015). Enhanced standards of marketability and productivity, as well as superior fulfilment of public and private sector initiatives, would be a consequence of advocating BIM to the South African government (Abdirad, 2017). Despite the fact that the idea of BIM has been around for more than twenty years, the ability to utilise it as a collaborative tool is a relatively new development as a result of greater software, hardware, and connection advancements (Barlish, 2012). Due to the model's accessibility from any place, cloud-based BIM environments have recently been shown to significantly increase the platform for collaboration (Bryde, 2012). The economic theory of creative destruction, which Schumpeter (1950) proposed, and Kopp (2021) elaborated on, explains how new technology frequently takes the place of obsolete ones. He contends that when the free market or capitalistic environment changes, the systems or institutions that are being replaced are destroyed.

1.7 BIM Consciousness Amongst Quantity Surveying Students

Pupils studying quantity surveying should be familiar with BIM, as it has many benefits when utilised efficiently. It is observed that a vast amount of Quantity Surveyors are not familiar with BIM. This research concentrates on quantity surveyors' comprehension of and instruction in BIM where university and institutional level training is the next logical step to adopting BIM in South Africa (Booyens, 2013). The advantages of BIM and other developments in the construction sector, which will increase output and reliability in metrics and budget control, should be made visible to quantity surveyors (Cerovsek, 2011). The emergence of BIM techniques, together with improvements in automated measuring and quantification, has cemented the way for more efficient digitization of quantity surveying procedures (Aiyetan, 2011). BIM has estimation capability and may be a helpful resource to enhance companies' current procedures (Ashworth, 2013).

2. RESEARCH METHODOLOGY

Both qualitative and quantitative methodologies were used in this study. In a brief period, a cross-sectional survey that was employed for this study was performed. A cross-sectional survey is undertaken by a singular respondent at a particular moment in time (Bearden, 1998). Studies that focus on visible, objectively driven variables and sample-educated persons should use cross-sectional surveys (Jaworski, 1993). Cross-sectional studies are primarily theoretically oriented and need the use of a variety of evaluation methods and scales (Moorman, 1998). The sample population consisted of corporations that conduct quantity surveying and construction works. A deliberate, non-probabilistic selection technique was adopted to determine only industry experts working for pertinent companies. Two quantity surveying instructors were scheduled for interviews as part of the qualitative methodology to converse about the implications of BIM learning in the quantity surveying curriculum. An interview outline with topics was created to ensure that particular subjects were covered during the interviews. The themes from the interview guide included budgetary restrictions, BIM software module responsibilities, and the present quantity surveying curriculum. A sample size is a limited number of respondents who are included in the study's target population. The sample size that is selected has an impact on the data that are obtained. Data that are accurate and dependable are ensured by the right sample size. A lower sample size is needed for qualitative research than for quantitative research. Morse (2002) proposes engaging 30 to 50 people for quantitative research. In the process of learning more about the consequences of incorporating BIM expertise into the current quantity surveying curriculum, two lecturers from the University of the Free State were sought and scheduled for interviews. The researcher entered the data collected from Google Forms into a Microsoft Excel coded datasheet and analysed it using Microsoft Excel, a Microsoft suite.
software application. The data gathered from the surveys were analysed, interpreted, and sorted into appropriate categories using Microsoft Excel. Microsoft Excel helps to reduce mistakes when transferring data.

Results
The empirical research was conducted utilizing a survey and interviews. The survey was intended for all quantity surveyors and construction firms in South Africa. In total, ninety (90) responses were received and completed. The researcher’s goal was to obtain at least 50 responses. The survey was accessible for a total of 29 days. The questionnaire included a few generic questions (questions 1–6) that sought demographic information, such as respondents’ age category, the province in South Africa where they work, the size of the firm for which they work, their occupation, professional registration, and the sector in which they operate. The survey induced 15 questions overall.

Two interviewees were questioned about the implications of incorporating BIM education into the existing quantity surveying curriculum in South Africa as well as what the present curriculum offers that would successfully enable graduates to use BIM software. The interviewees were encouraged to offer any additional ideas they had concerning the topics they were asked. The interviewees are senior lecturers at the University of the Free State as well as professional quantity surveyors. Following certain themes, interview questions were posed.

The empirical findings will now be evaluated and analysed utilising each question asked to the respondents.
BIM Implementation

The study found that most firms are not properly implementing BIM concerning quantity surveying responsibilities and that the proportion of firms that are successfully implementing BIM is 17.78% lower than that of those that are not utilizing BIM at all. 18.98% of respondents reported that their firms implement BIM moderately, which is 6.67% higher than firms that utilize BIM efficiently and 11.11% less than firms that do not employ BIM at all. See Figure 1 below for a visualization of BIM implementation levels.

![Figure 1: Scale of BIM Implementation](image)

BIM Awareness Amongst Respondents

This study found that respondents’ awareness level of BIM was high, with 38 respondents (42.22%) claiming they have level 4 (good) awareness and 16 respondents (17.78%) stating they have level 5 (excellent) awareness. 3 respondents (3.33%) reported having level 1 (poor) awareness of BIM, whilst 9 (10.00%) reported having level 2 (limited) understanding and 24 respondents (26.67%) reported having level 3 (moderate) awareness. See Figure 2 below for a visualization of BIM awareness levels.

![Figure 2: Scale of BIM Awareness](image)
This study found that, on average, respondents use a range of software applications to do their duties. Each of the software applications listed in the study may be categorised as BIM software since they all feature BIM components. One reason why respondents utilise many software packages is due to the functionality that each one offers. With 27.52% of all responses, WinQS was chosen by the largest percentage of respondents. DimensionX made up 25.19% of the total responses, followed by Construction Computer Software (15.12%), Autodesk (11.63%), and Navisworks (5.81%). Less than 5% of the other software programmes are employed by the respondents.

The study found that the vast majority of respondents believed that incorporating BIM into the quantity surveying curriculum would provide graduates with an advantage in the built environment. This option was selected by 77 people (85.56%). This is 80% more than those who feel BIM in the quantity surveying curriculum will not offer graduates a competitive advantage in the built environment. The data shows that 5 respondents (5.56%) said they do not believe quantity surveying graduates will gain a competitive advantage from BIM knowledge in the curriculum. 8 respondents (8.89%) stated that they are unsure whether BIM knowledge would offer graduates a competitive advantage. See Figure 3 below for a visualization of BIM awareness levels.

The study found that in South Africa, 63 respondents (56.76%) have used BIM. This represents a significant increase in BIM use in the local built environment. 27 respondents (24.32%) have utilized BIM on an international scale, whereas 21 respondents (18.92%) said the question does not apply to them. This suggests that 18.92% of the sample group has no prior experience with BIM.

The study found that the overwhelming majority of respondents stated that there is a high demand for more software-oriented courses in the quantity surveying curriculum, showing linkage to the main research question. This option was selected by 83 people (92.22%). This is 87.78% more individuals who feel software-oriented modules should be included compared to those who do not. According to the data, 4 respondents (4.44%) answered that they do not feel the quantity surveying curriculum should include more software-oriented modules given the fourth industrial

**Figure 3: Competitive Advantage for Graduate Quantity Surveyors**
revolutions. 2 (2.22%) respondents said that they are unsure if more software-oriented courses should be included in the quantity surveying curriculum. See Figure 4 below for data visualization.

Barriers to Implementing BIM in Firms

This study found that there is more than one barrier to implementing BIM in the respondents' workplace. The data shows that the majority of respondents, 45 (23.68%), believe that the high cost of BIM is the fundamental reason for not implementing BIM. 37 respondents (19.47%) believe that the awareness of innovation is limited. This demonstrates that a substantial number of respondents believe in the potential of BIM, but that it needs to be unlocked via a deeper understanding and expertise of the programme. Fear of change, according to 28 respondents (14.74%), is a hindrance to BIM implementation. This demonstrates that BIM is still in its early stages and that its benefits must be fully optimized before implementation by enterprises that choose to adhere to old techniques rather than take on the risks connected with BIM software.

Smaller companies may be more vulnerable to the fear of change. Team dynamics were seen as a hindrance to adoption by 23 respondents (12.11%). This might be because the team is now running efficiently without BIM, and the concern of changing the team dynamic and not reaping numerous benefits is omnipresent. It is a time-consuming process, according to 19 replies (10.00%). This might be due to a lack of information on the issue, which prevents the advantages from being realised quickly. 15 individuals (7.89%) expressed no concern regarding BIM. This suggests that it is not a requirement at this point in the built environment and that it is viable to operate without the programme. 4 respondents (2.11%) believe legislation prohibits BIM adoption, and 2 respondents (1.05%) anticipate job loss as a result of BIM implementation. This is an extremely low proportion, indicating that respondents do not feel BIM threatens the quantity surveyor's function. 17 respondents (8.95%) believe there are other reasons as opposed to the ones listed as barriers to successful BIM implementation. See Figure 5 below for a visualization of BIM implementation challenges.
The study found that respondents agreed that using BIM in practice will provide your company with a competitive edge. This option was chosen by 69 responders (76.67%). This is 67.67% higher than those who believe BIM will not give a competitive edge in the built environment. Following that, 12 respondents (13.33%) answered that they were unsure whether BIM would provide a competitive advantage. See Figure 6 below.

Competitive Advantage for Firms
Consequences of Incorporating BIM Education into South Africa's Current Quantity Surveying Curriculum

According to Interviewee A, under ideal conditions, the whole quantity surveying curriculum is necessary to grasp key portions of BIM, making it impossible to include in first-year classes. However, Interviewee A goes on to say that good BIM implementation may help students with curricular modules and that it is feasible to start reaping advantages before entering the workplace. The quantity surveying curriculum, according to interviewee B, "is quite active and comprises of several credits. Implementing additional learning into the curriculum to become skilled in BIM will be challenging. The time impact cancels out throughout the course of the programme, according to Interviewee B, who also notes that knowledge of BIM can help quantity surveying students accomplish some tasks and assignments faster than they would without the software.

CONCLUSION AND RECOMMENDATIONS
The study identified that no Building Information Modelling software learning is presented to quantity surveying students in the quantity surveying curriculum. The findings indicate that youth awareness of BIM is substantial, and all respondents, apart from 4.44%, utilize software programmes (such as BIM) in practice. Furthermore, 81.08% of respondents have utilized BIM locally or globally, 76.67% of respondents believe BIM expertise will provide graduates with a competitive advantage in the built environment. Additionally, 80.00% of respondents believe BIM learning in the quantity surveying curriculum will assist graduate quantity surveyors to execute their tasks more efficiently, and 92.22% of respondents believe the quantity surveying curriculum should incorporate more software-oriented modules (such as BIM education). Moreover, the interviews indicate that, although there are implications for integrating BIM learning into the quantity surveying curriculum, students are not acquiring adequate BIM exposure to be able to utilize the application as graduates entering the built environment. This information suggests that BIM competence is necessary and advantageous for quantity surveying graduates and that its absence from the curriculum will have negative consequences on graduates entering the profession. Although there are ramifications for incorporating BIM learning into the quantity surveying curriculum, students are not acquiring adequate BIM exposure to be competent to implement the application as graduates entering the profession. This study indicates that BIM competency is desired and valuable for quantity surveying graduates and that its omission from the curriculum will have a disadvantageous bearing on graduates entering the profession.

Some of the recommendations are as follows:
Curriculum modification should commence promptly, as it is a two-year process at most. The module can be written by a BIM software specialist, and a BIM expert can be recruited as a lecturer. Budgetary provisions can be established for software to be installed on computers owned by the institution and access to be made available to students at all times, ensuring that students incur no capital costs to utilize the programme.
BIM knowledge may be gradually introduced from the beginning of the quantity surveying curriculum to assist students in visualising certain components of the built environment and applying the software to accomplish university tasks more effectively.
External practical workshops that have no bearing on the quantity surveying curriculum must be offered, highlighting the relationship between the profession and software applications.
More seminars should be conducted to inform quantity surveying students about the relevance of software in the built environment and the benefits it provides.
More collaboration between professional bodies and quantity surveying firms is required to raise awareness and comprehension of BIM and its impact on quantity surveyors.
Quantity surveying firms must reconsider their present software capabilities and strategize for the future as BIM becomes increasingly entrenched in the built environment.

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Barriers to managing construction material waste in Zimbabwe

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ABSTRACT

Purpose of this paper: The drive towards sustainable infrastructure development calls upon construction organisations to adopt, *inter alia*, sustainable waste management practices. Despite this, developing countries have not adequately implemented sustainable waste management practices. This study aims to determine the barriers to effective construction material waste management in Zimbabwe and propose a response, including the potential of Industry 4.0 technologies to improve material waste management.

Design/methodology/approach: An exploratory survey design was adopted, which entailed the distribution of fifty (50) questionnaires to architects, civil and structural engineers, project managers, and quantity surveyors working for contractors and consulting firms in Harare. The data was analysed using descriptive statistics.

Findings: The key barriers to material waste management are lack of construction material waste management training and education, high cost of recycling facilities and technologies, lack of recycling facilities, lack of prioritisation of construction material management, and the perceived high cost of implementing material waste management measures. The main benefits of Industry 4.0 technologies relate to material waste management are enhanced detection of errors and omissions in the design, enhanced construction sequencing and planning, and pre-fabrication of elements.

Research limitations (if applicable): Given that the sample size is small, there is a need to be cautious when generalising the results to construction sectors in other countries or regions.

Practical implications (if applicable): The results highlight the need to integrate circular economy into built environment training, provide adequate material waste management infrastructure, and leverage Industry 4.0 technologies to improve waste management.

What is original/value of paper? The study contributes to the developing body of knowledge on sustainable construction waste management in Zimbabwe by identifying the key factors inhibiting the implementation of sustainable waste management practices.

Keywords: Construction, Industry 4.0, material waste, Zimbabwe
1. INTRODUCTION

The resultant effect of the exponential increase in world population and urbanisation has given rise to the need to expedite infrastructure developments. Statistics project that 90% of the urban migration in the year 2050 will occur in Africa and Asia[^1]. The construction industry is required to sustainably and economically develop infrastructure to accommodate the increased urban population. However, construction activities contribute to excessive material waste generation. Excessive construction material waste generation is a global problem affecting both developed and developing countries[^2, 3]. It is estimated that construction activities account for 35% of total solid waste generated globally[^4]. Construction material waste is defined as the difference between the value of those materials delivered and accepted on site, and those that are properly used and accurately measured in the work, deducting savings and adding loss of substituted materials and any materials transferred elsewhere[^5].

However, failure to properly manage construction material waste can have substantial economic, social, and environmental impacts. Material waste in landfills can cause serious water pollution through rainwater leaching and infiltration of surface and groundwater[^4]. Economically, material waste contributes to the loss of potential profits to contractors. On the other hand, construction material waste reduction has a plethora of benefits. Reduction of waste enhances natural resource conservation, which is an important facet of sustainability. Waste reduction reduces the amount of construction materials purchased, as well as the expenses associated with waste disposal[^1]. Accordingly, construction projects require efficient and cost-effective material waste management systems to reduce the generation of seemingly unusable material wastes[^6]. With the increasing awareness of the effects of material waste, construction waste management has been elevated to be an important function of construction project management[^3]. Various approaches to managing construction material waste have been developed and these can be grouped into three areas: waste classification; waste management strategies (avoiding, reducing, reusing, and recycling waste), and waste disposal technologies[^3]. It is important for waste management to encapsulate the development and implementation of strategies that are aimed at controlling and reducing the amount of waste generated, as well as to devise means by which inevitable waste can be reused or recycled[^7]. Environmentally friendly construction methods such as prefabrication and reducing wet trades have been shown to have a significant influence on material waste management.

Despite the potential impact of effective material waste management, developing countries such as Zimbabwe still lag in implementing sustainable waste management practices. Several factors are limiting the adoption of sustainable practices in material waste management. This study aims to identify the key barriers to effective material waste management and propose an intervention, including the potential of adopting Industry 4.0 technologies to contribute to improved material waste management.

2. REVIEW OF RELATED LITERATURE

Construction material waste is the difference between the value of the materials delivered and accepted on site and those properly used as specified and accurately measured in the work, after deducting the cost saving of substituted materials transferred elsewhere, in which unnecessary costs and time may be incurred by materials wastage[^5]. Typical examples of material waste include plastics, steel, glass, concrete, gypsum, and concrete. The management of material waste in construction is important to protect the environment, and human health, and enhance the construction economy. Every year the construction industry generates thousands of tonnes of construction waste most of which finds its final destination in landfill sites, river banks, and the environment. Alternative methods of
material waste management have been suggested including the three R’s of construction waste management, namely reduce, reuse, or recycle.

Several factors contribute to material waste in construction, and these depend on the type of construction method employed, the specific materials in use, and the stage of construction[8]. The top-five causes of material waste in construction are poor supervision, poor workmanship, poor storage facilities, improper handling, and improper storage[8]; a further cause being poor material control on building sites[8].

Inadequate management of material waste has adverse environmental, social, and economic impacts. Most construction waste has been found to contain harmful substances[5] to the environment and human health. Despite the notable effects of poor material waste management in construction, sustainable material waste management remains a challenge. The following section identifies the constraints to effective material waste management in construction.

2.1 Barriers to construction material waste management

Construction material waste management (CMWM) is impeded by factors, some of which stem from individual attitudes, and others that stem from organisational shortcomings concerning the matter. Some impediments are attributable to the nature of the construction industry, while some are due to a lack of support from the country’s economic and legal environment.

Regulations and their enforcement are pivotal in motivating construction professionals to implement construction management plans aimed at reducing waste. Extant studies[9] ascribe inadequate industrial performance standards for and regulation of waste management as barriers to waste management. During another study[10], it was revealed that laws and regulations pertinent to implementing waste management on construction projects are ineffective. National policies and regulations are limited and are not properly implemented[11]. Regulatory systems are not comprehensive enough to facilitate their effective execution and application on construction projects[10]. Available regulations lack specific detail and contain clauses that are 'very general' which makes it difficult to follow those clauses in execution[10]. The same study also revealed that in Shenzhen China, a regulation stipulating the charging of disposal of construction and demolition into landfills was put into effect from January 2014, but a method of charging had not been developed at the time of the study, which was published in 2017. The other notable barriers to material waste management include the lack of attention to waste management regulations, lack of waste management necessities in the national building codes, lack of incentives from regulatory authorities, and the fact that regulations do not make waste management mandatory all impede effective construction material waste management (CMWM)[12].

One of the main challenges encountered in the construction industry is the lack of skilled labour. Lack of skilled labour is a contributory factor to poor waste management practices[11]. The lack of skill and knowledge among workers impedes effective CMWM because it requires the cooperation and participation of labour, especially with regard to waste-handling methods[11]. There is an evident lack of training with regard to CMWM[13]. The available knowledge is acquired through work experience and is hardly supplemented by formal training sessions[13].

Another factor inhibiting the adoption of sustainable material waste management is the lack of definition of roles and responsibilities among construction practitioners with regard to CMWM[14]. An adverse concoction of lack of awareness and lack of responsibility from the design team results in failure to consider and implement material waste management during the design development stage of a construction project. There is a general misconception among architects and operatives that contractors and managers respectively, are responsible for material waste control. A related study[11] reports that architects do not usually give preference to a waste-minimising approach during the design and planning stage.

The focus on cost and profits also affects waste management strategies by both clients and contractors. Past studies have shown that both clients and contractors are primarily focused on the cost of the product, the time
in which it is completed, and its functionality, rather than sustainability practices [8, 15]. This was corroborated by another study [11], which reports that the lack of importance given by clients in imposing waste management practices into their projects is a major CMW deterrent factor. Clients are generally reluctant to offer the necessary support for CMWM activities [11]. The problem is aggravated by a procurement system, which tends to give more weight to traditional parameters such as cost, time, and quality, with little to no attention afforded to material waste implications [9]. Including material waste management plans and strategies during the selection of contractors will compel contractors to adopt and implement sustainable waste management strategies on projects.

Table 1 presents a summary of the barriers inhibiting the implementation of sustainable material waste management practices in construction.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Reference</th>
</tr>
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<tbody>
<tr>
<td>Lack of construction material waste management training and education</td>
<td>[8, 13]</td>
</tr>
<tr>
<td>Lack of prioritisation of construction material waste management</td>
<td>[8, 11]</td>
</tr>
<tr>
<td>Lack of clear waste management responsibilities among construction practitioners</td>
<td>[14]</td>
</tr>
<tr>
<td>Lack of awareness of material waste management among construction professionals</td>
<td>[16, 14]</td>
</tr>
<tr>
<td>Lack of skilled labour</td>
<td>[11, 13]</td>
</tr>
<tr>
<td>Inadequate management support for material waste management</td>
<td>[17, 3]</td>
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<tr>
<td>Non-affordability of recycling facilities and technologies / The high cost of material waste recycling</td>
<td>[18]</td>
</tr>
<tr>
<td>The perceived high cost of implementing material waste management measures</td>
<td>[15, 11, 9]</td>
</tr>
<tr>
<td>Lack of information with regard to the economic benefits of effective management of material waste</td>
<td>[11]</td>
</tr>
<tr>
<td>Lack of material waste recycling facilities</td>
<td>[16]</td>
</tr>
<tr>
<td>Lack of lack interoperability capabilities among existing waste management tools</td>
<td>[19]</td>
</tr>
<tr>
<td>Lack of incentives from authorities (government/municipalities)</td>
<td>[4, 12]</td>
</tr>
<tr>
<td>Inadequate availability &amp; implementation of national waste management regulations and policies</td>
<td>[16, 9, 12]</td>
</tr>
<tr>
<td>Lack of waste management requirements in the national building codes</td>
<td>[8]</td>
</tr>
<tr>
<td>Lack of proactive community engagement in material waste management</td>
<td>[20]</td>
</tr>
<tr>
<td>Lack of construction material waste data</td>
<td>[21]</td>
</tr>
<tr>
<td>Lack of material waste management plans</td>
<td>[11, 17]</td>
</tr>
<tr>
<td>Lack of client support for imposing waste management practices into their projects</td>
<td>[15, 9, 17]</td>
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</tbody>
</table>

The preceding discussion calls upon the construction industry to adopt innovative interventions to improve material waste management. In today’s world, the construction industry can leverage Industry 4.0 technologies to improve construction material waste management.

2.2 The contribution of Industry 4.0 technologies in construction materials waste management

Industry 4.0 involves the integration of the manufacturing environment (machinery, factories, warehousing facilities) with the Internet of Things (IoT) so as to connect industrial businesses worldwide and control their manufacturing facilities through cyber-physical systems, by sharing information that perpetuates actions [22]. A key Industry 4.0 technology is Building Information Modelling (BIM). BIM is a key tool for establishing innovative applications for the construction industry by providing an additional layer of data that is able to interact and collaborate in real-time throughout the project lifecycle [22]. The application of BIM has brought forth methods to eliminate construction waste causes during the design stage [23]. BIM presents the ability to virtually construct a building prior to construction, thus enabling construction practitioners to assess and verify the constructability. Employing BIM during the project design process can eliminate unnecessary work during the construction stage with the potential to cause material waste [24]. BIM has the potential to reduce rework - a major cause of construction material waste during the construction phase of the project [23]. This is because any alterations to the design are automatically updated, and hence, rework caused...
by omissions will be considerably decreased. In addition, BIM helps to detect errors, clashes, and omissions in the design, a function that is missing when 2D drawings are used.

Another Industry 4.0 concept is off-site manufacturing / prefabrication or off-site construction. Prefabrication is the process of planning, designing, fabricating, transporting, and assembling building elements for rapid site assembly to a greater degree of finish than in traditional piecemeal on-site construction. Prefabrication serves as a solution to poor workmanship and helps to reduce waste which is attributable to wet trade operations such as the pouring of concrete, bricklaying, plastering, tiling, and screeding. It reduces waste related to plastering by up to 100%.

The other Industry 4.0 technologies with an application in waste management are ‘semi-driverless vehicles’ utilised to collect waste, numerous sensing devices monitoring the collection of the waste, drones being deployed to monitor landfills, and 3D printers programmed to recycle various kinds of plastics. Technologies that promote waste sorting capabilities are critical for waste management to alleviate the cost, and health, safety, and environmental hazards associated with manual sorting. Robotic sorting presents a solution to the issues associated with manual sorting. A study conducted in Bangladesh, India developed a conceptual design of an ‘intelligent automated (robotic) waste sorting system’ with features that would assist in overcoming the shortcomings prevalent in waste sorting systems. The system would be programmed to sort waste into different categories, such as organic waste, metals, and plastics. This sorting of waste into categories would be performed using voltage sensors. The importance of robotic technology in construction waste management was corroborated during another study, which affirms that robotics improve the efficiency of sorting and recycling.

In summary, the study will consider the potential of BIM, offsite manufacturing, 3D printing, and robotics to enhance material waste management.

3. RESEARCH METHOD
The study adopted an exploratory quantitative design wherein fifty (50) structured questionnaires were distributed to purposefully selected construction professionals in Harare. The population of the study comprised architects, civil / structural engineers, and quantity surveyors selected from construction and consulting firms. A quantitative research approach is preferred because it is specific, well structured, has been tested for reliability, and can be explicitly defined and recognised.

Before distributing the questionnaire, it was reviewed by three experts selected from consulting firms (1) and contractors (2) to identify errors, omissions, and areas that required improvement. The selected experts, who included an architect, an engineer, and a quantity surveyor, had more than 10 years of work experience and a Bachelor’s degree. The questionnaires were distributed via email, and some were hand-delivered to the respondents’ places of work. The questionnaire consisted of three separate sections which addressed the demographic information of respondents, the barriers to effective CMWM, and the application of selected Industry 4.0 technologies to CMWM, respectively. The barriers included in the questionnaire were generated from literature as presented in Table 1.

The data obtained from the questionnaires was captured in a Microsoft Excel spreadsheet, from which descriptive statistics such as mean, mode, and percentages were used to analyse the data. Mean scores (MSs) were computed and used to ascertain the level to which certain barriers militated against effective material waste management, and the extent to which respondents deemed selected Industry 4.0 technologies to enhance construction material waste management.

4. RESEARCH FINDINGS
4.1 Demographic profile of the respondents
A total of 21 responses were received in response to the 50 questionnaires distributed to consulting firms and general contractors, representing a response rate of 42%. Of the completed questionnaires 12 (57.1%) were completed by respondents employed by general contractors, and 9 (42.9%) were completed by respondents who are employed by consultancy firms. Considering that the sample size is small, the results can be considered as indicative. The low response rate is, however, consistent with past studies in construction management. During a Malaysian study [31], 45 questionnaires were distributed and 14 usable responses were received and analysed.

The qualifications of the respondents include Diploma (19.1%), Bachelors Degree (52.4%), and Masters Degree (28.6%). With regards to years of industry experience, the results show that 52.4% of the respondents have 0-5 years of experience, 28.6% of the respondents had 6-10 years of experience, 9.5% of the respondents had 11-15 years of experience, and 9.5% of the respondents had 16 years and more years of experience.

4.2 Barriers to effective construction material waste management

Table 2 indicates the extent to which respondents rank the barriers to effective CMWM in terms of percentage responses from 1 (not at all) to 5 (major), and MSs ranging from 1.00 to 5.00, the midpoint score being 3.00.

Table 2 Barriers to effective CMWM

<table>
<thead>
<tr>
<th>Barrier</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of CMWM training and education</td>
<td>4.43</td>
<td>1</td>
</tr>
<tr>
<td>Recycling facilities and technologies are not affordable</td>
<td>4.25</td>
<td>2</td>
</tr>
<tr>
<td>Lack of material waste recycling facilities</td>
<td>4.25</td>
<td>2</td>
</tr>
<tr>
<td>Lack of prioritisation of CMWM</td>
<td>4.24</td>
<td>4</td>
</tr>
<tr>
<td>The perceived high cost of implementing material waste management measures</td>
<td>4.19</td>
<td>5</td>
</tr>
<tr>
<td>Lack of awareness of material waste management among construction professionals</td>
<td>4.05</td>
<td>6</td>
</tr>
<tr>
<td>Lack of clear waste management responsibilities among construction practitioners</td>
<td>4.05</td>
<td>6</td>
</tr>
<tr>
<td>Lack of proactive community engagement in material waste management</td>
<td>4.00</td>
<td>8</td>
</tr>
<tr>
<td>Lack of incentives from regulatory authorities (government / municipalities)</td>
<td>3.95</td>
<td>9</td>
</tr>
<tr>
<td>Inadequate management support for material waste management</td>
<td>3.95</td>
<td>9</td>
</tr>
<tr>
<td>Lack of information with regards to the economic benefits of effective management of material waste</td>
<td>3.90</td>
<td>11</td>
</tr>
<tr>
<td>Inadequate availability and implementation of national waste management regulations and policies</td>
<td>3.86</td>
<td>12</td>
</tr>
<tr>
<td>Lack of material waste management plans</td>
<td>3.75</td>
<td>13</td>
</tr>
<tr>
<td>Lack of waste management requirements in the national building codes</td>
<td>3.71</td>
<td>14</td>
</tr>
<tr>
<td>Inadequate / lack of construction material waste data</td>
<td>3.65</td>
<td>15</td>
</tr>
<tr>
<td>Lack interoperability capabilities among existing waste management tools</td>
<td>3.50</td>
<td>16</td>
</tr>
<tr>
<td>Lack of client support for imposing waste management practices into their projects</td>
<td>3.33</td>
<td>17</td>
</tr>
<tr>
<td>Lack of skilled labour</td>
<td>3.24</td>
<td>18</td>
</tr>
</tbody>
</table>

The barriers ranked 1st to 4th have MSs > 4.20 ≤ 5.00, which suggests that respondents deem that ‘lack of construction material waste management training and education’, ‘costly recycling facilities and technologies’, ‘non-availability of recycling facilities’, and ‘lack of prioritisation of construction material waste management’ affect the adoption of sustainable material management practices between a near major to a major / major extent. The results highlight the need to integrate construction material management principles and techniques into built environment training, and the provision of affordable recycling facilities and technologies. Furthermore, Jain [11] states that clients do not impose waste management practices on their projects, which impedes effective construction waste
management. The findings of this study affirm the results gathered in a previous study \textsuperscript{13} which confirmed that there is an evident lack of training with regards to material waste management.

The barriers ranked 5\textsuperscript{th} to 17\textsuperscript{th} have MSs > 3.40 ≤ 4.20 suggesting that respondents deem the barriers to constrain effective material waste management between a moderate to a near major / near major extent. The leading barriers within this cluster are ‘the perceived high cost of implementing material waste management measures’, ‘lack of waste consciousness amongst construction professionals’, ‘lack of clear waste management responsibilities among construction practitioners’, ‘lack of attention to waste management from the community’, and ‘lack of incentives from authorities’. The findings of the study are consistent with the findings of a previous study which revealed the lack of affordable facilities to foster waste management, is a prominent impediment to effective construction material waste management. In addition, past studies show that low levels of waste management awareness lack of attention to construction material waste management from the community\textsuperscript{12}, and inadequate implementation of regulations and policies\textsuperscript{11} affected construction waste management.

The barriers ranked 17 to 18\textsuperscript{th} have MSs > 2.60 ≤ 3.40 suggesting that they have between a near minor to moderate / moderate effect on the implementation of sustainable construction material waste management. The barriers within this cluster are ‘lack of support from clients and other professional consultants’ and ‘lack of skilled labour’. The results are consistent with past studies \textsuperscript{11, 16}, which showed that lack of imposition of management practices by clients and lack of skilled workers inhibit sustainable construction waste management.

4.3 How selected Industry 4.0 technologies can enhance material waste management

Table 3 shows the respondents’ assessment of the perceived benefits of selected Industry 4.0 technologies to enhance material waste management. Given that all the MSs are > 3.00, it can be inferred that respondents deem that Industry 4.0 technologies can enhance material waste management to a major, as opposed to a minor extent.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>MS</th>
<th>Rank</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced detection of errors and omissions in the design</td>
<td>4.45</td>
<td>1</td>
<td>BIM</td>
</tr>
<tr>
<td>Offsite manufacturing / prefabrication of building elements</td>
<td>4.40</td>
<td>2</td>
<td>Modularisation</td>
</tr>
<tr>
<td>Enhanced construction sequencing and planning</td>
<td>4.30</td>
<td>3</td>
<td>BIM</td>
</tr>
<tr>
<td>Facilitate precise taking-off</td>
<td>4.25</td>
<td>4</td>
<td>BIM</td>
</tr>
<tr>
<td>Elimination of poor workmanship</td>
<td>4.10</td>
<td>5</td>
<td>3D Printing</td>
</tr>
<tr>
<td>3D and 4D visualisation of the proposed site layout (placement of equipment and material)</td>
<td>3.95</td>
<td>6=</td>
<td>BIM</td>
</tr>
<tr>
<td>Enhanced synchronising the design with the site layout</td>
<td>3.95</td>
<td>6=</td>
<td>BIM</td>
</tr>
<tr>
<td>Sorting and recycling of construction material waste using robots</td>
<td>3.94</td>
<td>8</td>
<td>Robotics</td>
</tr>
<tr>
<td>Real-time monitoring waste waste-causing practices on construction sites</td>
<td>3.78</td>
<td>9</td>
<td>Drones</td>
</tr>
</tbody>
</table>

The benefits ranked 1\textsuperscript{st} to 4\textsuperscript{th} have MSs > 4.20 ≤ 5.00 suggesting that respondents deem the adoption of the selected Industry 4.0 technologies to contribute to the realisation of benefits between a near major to a major / major extent. The results suggest that the adoption of BIM can contribute to material waste management by enhancing the detection of errors and omissions during design, improving sequencing and planning of work, and facilitating precise taking off. In addition, respondents note that the adoption of modularisation wherein components of the building can be prefabricated off-site contributes to reduced material waste. The results are consistent with those of Tam \textit{et al.} \textsuperscript{26}, whose study reported that prefabrication reduced wet trade-related waste such as waste arising from plastering,
tiling, and screeding. Another related study\textsuperscript{[23]} revealed that the use of BIM mitigates errors and omissions during the design stage. Excessive quantification of materials has been reported as a contributor to material waste \textsuperscript{[16]}.

The results further show that there is great potential to enhance material waste management through the adoption of 3D printing, drone technology, and robots. Robots enhance material waste management through improved sorting and recycling of construction materials (MS = 3.94) while drone technology enhances real-time monitoring of waste-causing practices on construction sites (MS = 3.78). The use of 3D printing can help to eliminate poor workmanship (MS = 4.10), a potential source of waste on construction projects.

7. CONCLUSIONS AND RECOMMENDATIONS

The study investigated the barriers to material waste management in construction in Zimbabwe and the potential benefits of adopting Industry 4.0 technologies to improve material waste management. The key barriers to material waste management are lack of construction material waste management training and education, high cost of recycling facilities and technologies, lack of recycling facilities, lack of prioritisation of construction material management, and the perceived high cost of implementing material waste management measures. The results suggest that technical, economic, and human factors inhibit the adoption of sustainable material waste management. The results highlight the need for an adequate material waste management infrastructure such as physical facilities, regulations, and policies. In the absence of regulation, the need for incentives (tax or subsidies) cannot be overstated. More importantly, the results reinforce the need for collaborative action toward material waste management rather than leaving it to contractors to manage. With regards to training, the study highlights the need to integrate aspects of material waste management into the built environment curriculum to prepare would-be graduates for such application in practice.

The results further highlight the importance of Industry 4.0 technologies to enhance the management of material waste in construction. The results showed that selected Industry 4.0 technologies such as BIM can enhance material waste management through enhanced detection of errors and omissions in the design, enhanced construction sequencing and planning, and taking off. In addition, modularisation will enhance the prefabrication of building elements and hence reduce wet trades on site. The study recommends that construction industry practitioners integrate Industry 4.0 technologies into material waste management. The main limitation of the study is the small sample size, which affects the generalisation of the results to construction sectors in other countries or regions. Nonetheless, the results from the exploratory study can be used to inform future studies on the subject.

8. REFERENCES


A critical review of the potential of decentralised energy systems in rural settlements. The case of uMkhanyakude district in South Africa

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ABSTRACT
Purpose of this paper
Worldwide energy security is one of the key drivers needed for a thriving economy and a reliable and effective source of energy is of paramount importance as this also creates room for social equity. The purpose of this paper is to present a critical review of the literature on the status of decentralization energy systems in South African rural areas, with a case study in the uMkhanyakude district.

Design/methodology/approach
This study is based on secondary data gathered from existing literature related to the opportunities offered by decentralising energy systems in rural communities to meet uMkhanyakude district community demand. The SWOT (Strength, Weaknesses, Opportunities and Threats) analysis was used to systematically analyse and synthesize data.

Findings
The findings from this study reveal the key challenges and opportunities related to decentralisation of energy systems in rural settlements, with specific focus on the uMkhanyakude district of South Africa.

Research limitations/implications (if applicable)
This research is part of a PhD study. In this paper, a review of the existing literature on energy provision in rural communities in South Africa is outlined and will feed into fieldwork activities that will start later on when ethical clearance will be granted.

Practical implications (if applicable)
A decentralized energy scenario for rural electrification can serve as a long-term solution; however, the decentralization of energy systems in South African rural areas remain a grey area in the energy supply chain. Therefore, this study seeks to uncover challenges and opportunities related to decentralization of energy in the uMkhanyakude district.

What is original/value of paper
To date, energy supply in rural community is still a big challenge across South Africa. Therefore, this study seeks to identify challenges and opportunities related to decentralised energy supply in rural communities with the focus in uMkhanyakude district.

Keywords: Decentralised systems, energy supply, rural human settlements, South Africa
1. **INTRODUCTION**

Energy plays a crucial part in the lives of humans as it is needed for most of the everyday activities and for the socio-economic development of a country such as South Africa. For long time, coal has been the main source of energy in the world and today it still counts for a significant amount of energy production. Coal is estimated to produce 40% of the world’s energy which leaves a negative carbon footprint on the planet \(^1\). The reality is that energy is the source of productivity of a community, district, and country as a whole and a shift towards a low-carbon electricity system is key to preserving the well-being of this planet \((\text{ibid})\). In the drive to attaining a low-carbon emitting energy system, it is rather important that inclusivity is endorsed in access to energy to ensure that no one is left behind. The lack of access to energy is mostly evidently seen in rural areas where people continue to live without having access to power. Inclusivity and leaving no one behind, is among the Sustainable Development goals of the United Nations for the 2030 Agenda and as such, greater efforts to ensuring that energy reaches everyone need to be made regardless of the challenges.

Climate change has further put pressure on people as there has never been a more eminent time to try and transition towards newer and more sustainable forms of energy generation and supply. The transitioning towards a greener and more sustainable future will ensure the future of the planet and generations. In fact, current forms of energy supply, mostly linked to thermal power stations are not only unsustainable to the environment, but also fail to reach some areas in the country, leaving a certain population without access to power \(^2\). The combustion of fossil fuels to produce energy results in a significant amount of greenhouse gas emissions that contribute to global warming and climate change \(^3\). This clearly indicates that there is a definite need to shift from traditional forms of energy generation. Most sources of renewable energy result in little to no emissions, even when considering the full life cycle of the technologies, and this therefore creates an opportunity to explore the use of such technologies to make a positive environmental impact \((\text{ibid})\).

This review paper focuses on the uMkhanyakude district located in the Northern regions of KwaZulu-Natal and considered as a rural district.

2. **An overview of decentralized energy systems**

Decentralized energy systems represent a paradigm shift in the way energy is generated, distributed, and consumed. These systems aim to provide cleaner, more efficient, and locally controlled sources of energy, diverging from the traditional centralized energy grid model. Decentralization essentially refers to a system that uses renewable energy (RE) technologies such as solar, wind power and biomass fuels to generate, store and distribute power in a localised way and these systems are sometimes referred to as micro-grids \(^2\). Decentralized energy systems can also be described as small-scale generation units that deliver energy to the local consumers within a given area. These units can either be in stand-alone forms or else can be connected to other systems nearby through a network to share resources, i.e., the sharing of surplus energy \(^4\).

Decentralized energy systems differ from centralized energy systems which are much larger in scale and deliver energy through a vast distribution network \((\text{ibid})\). The images below highlight the differences between centralized and decentralized energy systems.
Decentralized energy systems, essentially involve the generation of energy closer to the point of use. The primary purpose is to increase energy resilience, reduce transmission losses, enhance sustainability, and offer greater control to end-users. Decentralized systems utilize a diverse range of energy sources, including:

- Solar power: Photovoltaic panels on rooftops or in local solar farms.
- Wind power: Small-scale wind turbines or community wind projects.
- Biomass: Local bioenergy facilities using organic materials.
- Combined Heat and Power (CHP): Simultaneous generation of electricity and heat at the local level.
- Micro-hydro: Small hydroelectric systems for local water resources.
- Energy storage: Batteries and other energy storage technologies.

According to the section 153 of the South African constitution, all South African municipalities have the responsibility to ensure the provision of services to communities in a sustainable manner (including the reticulation of energy\(^5\)), as well promoting economic and social development. This is a clear statement that has been set out by the new democratic government; however, as the data would show, much work is still required for this target to be reached, since a relatively large population has no access to power for lighting and cooking. This knowledge then raises the question of the state of electricity and electrification in South Africa.

3. **The state of electricity in South Africa**

When considering the state of electrification within the residential sector, the International National Electrification Program (INEP) has recognised a significant and positive impact across the country\(^6\). In the Post-apartheid era, the South African government understood that a large number of households did not have adequate access to electricity for services such as cooking, heating, and lighting and through communication and in following the constitution, it was concluded that electricity is a basic need and so a program to having access to basic electricity was initiated. This program was subsequently titled as the International National Electrification Program (INEP) and it was a program that was responsible for achieving universal electrification by the year 2025, and the INEP was responsible for the planning, project management and funding bulk infrastructure grid and non-grid connections for households\(^7\). The success of this program had it successes as this government intervention claims that 89% of households amongst metros have been electrified, however, rural

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ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
household electrification levels only stand at 55% and this is true for the case in uMkhanyakude district (8). The significant difference in levels of electrification is justified by the fact that it is extremely costly to extend grid connection to rural areas as well informal settlements in the urban context (ibid). Centralized grid electrification systems have been the traditional means of generating and supplying reliable electricity, however, connection to distant grids showed to be too expensive or non-viable for it to reach rural areas such as uMkhanyakude district (9). Still, the South African energy utility that is tasked with ensuring electricity generation (ESKOM), distribution and supply to citizens has not been efficient of recent times (up to 10 years) as it has struggled to provide a steady of energy. These challenges put further pressure in the attempt to electrify rural communities as well.

There are many factors that have led to the materialization of this problem, but for over more than ten years, a historic supply and demand imbalance in SA’s single buyer energy model has resulted in intensive load shedding continuing countrywide during 2021(10). As of November 2021, load shedding had occurred for 1 136 hours, with an upper limit of 2 455 GWh; a 37% YTD increase compared to the 859 GWh upper limit of energy shed in 2020(11). This equates to 76% of the full year load shedding in 2020. Load shedding has been driven by a combination of factors, including:

- Delayed commissioning and underperformance of new-build coal generation capacity.
- Degradation of the existing Eskom coal fleet declining from 94% in 2002, 65% in 2020, 67% in 2019/20 and to 61.31% for 2021.
- An alarming and continued trend increasing Unplanned Capability Loss Factor (UCLF) of up to 15 300 MW was experienced in H1 2021(11).

What has remained true about life is that where there exists a problem, there is opportunity to exploit and solve the problem and a decentralized energy option for rural electrification can be possible. South Africa faces several challenges and issues that are related to electricity generation and supply as it has struggled with power generation shortages for many years, leading to the frequent blackouts and load shedding. This situation has been primarily attributed to aging power infrastructure, underinvestment in new power generation capacity, and technical issues at power plants. The term referred to as “Load shedding”, is essentially a controlled system of rolling blackouts, and have since become a common occurrence to prevent the collapse of the grid due to insufficient electricity supply. In order for ESKOM to be able to support its financial sustainability and infrastructure investments, electricity tariffs have been regularly adjusted, which has led to higher energy costs for consumers and businesses. The unreliable electricity supply posed significant challenges to industries, including mining and manufacturing, which rely heavily on consistent power for their operations (ibid). South Africa are trying to make adjustment to the energy crisis and has been making efforts to transition to renewable energy sources, including wind and solar power. The Renewable Energy Independent Power Producer Procurement Program (REIPPPP) is aimed to increase the share of renewable energy in the country's energy mix. This can be viewed as a good step to supplying a clean source of energy and from this decentralised energy option can be adopted to support rural electrification programs.

4. Decentralized renewable energy options.

Decentralized energy options for electrification hold the potential to address many social ills in South Africa, while also providing clean energy to citizens. However, when considering RE, it is important to consider the climatic conditions of the area, as this will allow to make an informed decision on which RE technology to implement in a given area. South Africa is a country that has the potential to maximise greatly on solar energy as it has been said to receive an average of 2500 hours of sunshine in a year (12). This makes South Africa a prime location to utilize solar energy systems to offset the energy crisis. Wind energy is also fairing closely with solar energy in South Africa as the total wind power potential is said estimated to be 6700 Gigawatts (GW) (ibid).
Given the ever-rising cost of traditional fossil fuels-based energy, renewable energy is fast becoming a viable option for the country to solve its current electricity crisis of load-shedding\(^{(13)}\). The continuation of burning of fossil fuels without making any changes threatens the very existence of life on earth as we know it, as the burning of fossil fuels is the direct cause of many environmental issues such as air pollution and climate change \(^{(14)}\). In response to the global climate change crisis that is largely exacerbated by the traditional forms of energy production (thermal power stations), South Africa has since adopted a policy framework to increase the share of renewable energy in the national energy mix \(^{(10)}\). The framework drafted by The Department of Mineral Resources and Energy (DMRE) has gazetted changes to the Electricity Regulations on New Generation Capacity as opposed to having one single entity being responsible for the whole country’s energy supply \((ibid)\). These changes clarify the rules applicable to municipalities when requesting determinations under Section 34 of the Electricity Amendment Act and allow municipalities in good financial standing to source or buy new generation capacity and develop their own power generation projects. These scenarios suggest that municipalities may look into decentralized renewable energy and as the cost of renewable energy projects continues to decrease, it becomes possible to look into decentralization as an option to increase access to electricity even in rural areas. The South African government has realised the need for the green transition and has developed policies and projects aimed at fostering a diversification of energy and implementation of renewable energy. This movement has seen some success as it has seen 92 power producers contribute to a considerable 6300 Mega-Watts (MG) into the power grid and this mainly comes from solar (4.6 to 6.6 KWH/m\(^2\) of radiation level) and wind energy \(^{(12)}\). According to a study conducted by Mulaudzi, Muchie and Makhado \(^{(15)}\) (2012: 233), “South Africa has the best solar resources in the world, average daily solar radiation varies between 4.5 and 7 KWH/m\(^2\)”. Solar potential tends to stand out in the Northern and Southern African regions. Abdelrazik et. al. \(^{(16)}\) (2022: 11363) also stated that “South Africa has the potential for concentrating solar power of 43,275 TWh/year and potential for solar photovoltaic of 42,243 TWh/year”. This statement adds testament to the high energy potential that exists in the renewable energy field. Furthermore, due to erratic power supply, rising cost of grid electricity, and remoteness of areas, South Africa has seen a growth in off-grid Photovoltaic (PV) solar systems as 43.81 MW of registered PV power systems are in use as roof top units \((ibid)\). RE energy systems hold a lot of potential to make a significant improvement in everyday lives of people in rural areas too.

Improved access to energy to all households and citizens holds the potential to significantly make a positive impact on the livelihood of the people residing in rural areas \(^{(2)}\). The demand for energy, especially in developing countries is quite high and that creates many challenges such as keeping economic growth constant while also fostering for a more sustainable and greener future. South Africa owes the highest energy demand to home appliances such geysers, stoves, lighting etc. as the country’s residential energy consumption is at 17% of total energy consumption and can go as high as 35% during peak energy demand \(^{(17)}\). The beckoning energy poverty crisis is also made worse by the high cost of electricity and in areas where unemployment rate sits relatively high, and this brings about social issues too. Therefore, decentralized energy interventions can realise important social benefits in South Africa’s lower income households \((ibid)\). Approaching rural electrification through a decentralized manner provides us with an opportunity to overcome the challenge of rural electrification. The whole concept of decentralizing energy systems is essentially to put power sources closer to the end users. It is understood that connecting electricity to areas in remote lands is a costly exercise, however, when comparing decentralized renewable technologies to the traditional centralized technologies and methods of getting power to the consumer, the upfront cost of a decentralized energy system is lower, and this can also help avoid the high costs transmission and distribution of grids \(^{(2)}\). Decentralized energy systems operate on smaller scales and are much closer to the consumer of energy and this also reduces the load on the demand of energy from the centralized grid and for a rural district such as uMkhanyakude, decentralized energy has the potential to work. It is a well-known fact that energy is in essence the driver of an economy, and such interventions can yield positive outcomes for the uMkhanyakude district.

The dominant economic drivers in the uMkhanyakude district are retail, catering, and accommodation
sectors as they accounted for R 1.45 billion in the year 2011 \(^{(18)}\). Agriculture and community services are also considered among the main economic drivers of the district as well as it accounts for 12.7% and 30.6% of the gross value add (GVA) respectively. The uMkhanyakude district boasts great opportunity in the tourism and trade industry due to visual appeal, biodiversity, heritage, and culture of the district. This creates opportunities for the existence of small medium enterprises in the tourism and sector as it is situated before the Mozambique border, and this may open opportunities for other economic activities and as such, having a reliable source of power can boost the local economy. However, in practical terms, to make this happen the focus should be shifted from trying to source energy from large scale centralized energy systems to systems small-scale renewable technologies which has the potential to contribute significantly to the national energy grid \(^{(19)}\). For a decentralized energy system to work efficiently, the right renewable technologies need to be selected for the specific environment or area as this will ensure that harnessing through nature is made effective as possible.

There are several technologies that can be employed in support of the shift to decentralized energy systems and current literature suggests that the most easily accessible and applicable to the uMkhanyakude district is Solar power, because of its high potential and availability at any location \(^{(3)}\). Distributed photovoltaic (PV) is a well-recognised technology that can be used to meet small-scale rural energy needs in an affordable, reliable, and carbon-neutral manner \(^{(20)}\). The uMkhanyakude district receives a lot of sunlight and as such, solar power technology has to potential to make a considerable difference in the energy supply. Other forms of technology that can be used include wind power. Wind power is site-specific based, and research would require to be conducted prior to implementation of such a technology. The uMkhanyakude district is also a district that conducts a lot of agricultural activities. This therefore creates an opportunity for exploring renewable energy technologies such as Biomass energy. Bioenergy is made available from biomass, e.g., crops, residues and other biological materials that could be used to produce chemical energy, i.e., gas that could be converted into electricity \(^{(20)}\). Biogas, which is a mixture of methane and carbon dioxide, is produced by breaking down biomass, particularly wet organic matter like animal dung, leftover food or human waste \((ibid)\). Other technologies of renewable energy can be used for decentralized energy systems such as geothermal energy and Hydro energy; however, these technologies might not necessarily be the most practical for the area in question.

4.1 Opportunities for decentralized energy systems in uMkhanyakude

Renewable energy (RE) technology can help in generating local economic activities. Job creation and improved livelihood facilities can significantly improve the productivity of rural areas such like in the uMkhanyakude district where the unemployment rate to persons under the age of thirty-five sits at a staggering 70% \(^{(18)}\). Addressing the unemployment crisis through investment in decentralized energy systems shows the potential to allow for an environment that will not only foster economic expansion, but also work improve the environmental conditions of the planet. Decentralisation also helps in institutional development, and it increases space for community actors as well \((ibid)\). By taking the route of decentralized energy systems for rural electrification, the opportunities also extend to improving life especially for children and women who are in vulnerable or rural communities. Modern energy services can reduce the time required for household activities and the burden of collecting fuel particularly for women \(^{(21)}\). This will leave women with more time for learning, leisure, and economic activities \((ibid)\). Further, collecting water is also a very tedious job which can be reduced with the help of electric water pumps to provide clean water. Access to radio and television increases the opportunities for awareness, education, and leisure time spending. The opportunities associated with rural electrification through decentralized energy systems are almost endless.

New revenue sources or a new fiscal need to be created as more economic activity increase the tax base for improving service provision in rural communities too \(^{(22)}\). It can also help generate extra income for landowners and land-based activities for people in rural areas, where people often have large areas of land. For example, farmers and forest owners who integrate renewable energy production into their activities have...
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diversified, increased, and stabilised their income sources. Although RE tends to have a limited impact on local labour markets, it can create some valuable job opportunities for people in regions where there are otherwise limited employment opportunities. Renewable energy systems can create direct jobs, for example, in operating and maintaining equipment, however, where the more sustainable jobs in terms of their longevity would be indirect, coming from the lines of renewable energy supply-chain (manufacturing, specialised services) (ibid). Adopting the decentralized energy systems also creates new opportunities for entrepreneurial ventures in an array of different trades too.

Renewable energy technologies provide remote rural regions with the opportunity to produce their own energy (electricity and heat in particular), rather than importing conventional energy from outside and what is of most importance to understand is that being able to generate reliable and cheap energy can trigger economic development. Even though a wide range of socio-economic and environmental arguments are in favour of Distributed Renewable Energy systems (DRE), in practice there are also a series of barriers to overcome (4).

4.2 Challenges associated with decentralized energy systems.

Decentralized energy systems that primarily use renewable energy as the main source of energy remain the best option to electrify rural areas, however various challenges characterise the attempt to adopt these forms of energy supply into rural areas (23). Decentralized energy systems offer numerous benefits, but they also come with several challenges that need to be addressed for their successful implementation. The renewable energy strategy is expected to deliver on three main areas namely, energy security, climate change mitigation, and economic development (job creation) (24). However, this is not always the case and there can be significant trade-offs among them. For example, large biomass heat and power plants can generate new employment opportunities in rural communities, however, it may cause a negative carbon-dioxide balance because of land-use change and the transportation of feedstock over some long distances and this becomes rather counterproductive as fails to address one of the key main areas the renewable energy strategy aims to tackle (21). Further, most renewable energy initiatives are also capital-intensive activities, and energy represents a small share of employment in regional economies. In addition, small-scale installations typically source labour and equipment from international suppliers, so the impact at the community level in terms of job creation can be said to be rather limited (ibid).

There are many factors that remain a real threat to the widescale adoption of decentralized energy systems in rural areas some of which include, but are not limited to the following:

- Lack of specific policy - This is a crucially important for the widescale adoption of decentralized energy to rural areas, as the lack of off-grid policy hampers and delays investments into decentralized renewable energy options (25). The country Sierra Leone, developed policies to promote the adoption of RE for rural electrification and this boosted investor confidence from donors and international organisations and so this shows the importance and effectiveness of policies to boast decentralized energy options (23). Nyarko et.al., (2023: 9) stated that “Sierra Leone is a country that has developed policies to promote the growth of RE for rural electrification. Financial institutions and international organizations started showing confidence in investing in Sierra Leone after RE policies and regulations were aligned to create a conducive environment to invest in mini-grids”. Policies should also be designed in such a way that it not only caters for the provision and supply of decentralized energy, but it needs to factor in a regulatory framework that seeks to ensure that the these localised energy stations remain in good condition so that it also becomes possible to scale them up in future (ibid). When policies are targeted towards the acceptance of the adoption of decentralized energy options or mini-grids, they boost stakeholder confidence in investing in such technologies. Socio-cultural challenges- when working with communities, it is usually advised that they are consulted prior to make any proposed developments as...
this could potentially be the determining factor if whether or not a idea is adopted and so as a result, the willingness of the community is a crucial driver too. One of the inhibiting factors with decentralized RE for rural electrification is the limited and unknown number of productive end-user customers who could generate revenue incomes from this electricity generation in the area (26).

- Lack of access to infrastructure - rural areas are often burdened by a lack of infrastructure such as transport, education and health facilities and this usually means that there is shortage or a lack of competent and knowledgeable human capital about RE (26). The challenges of overcoming long distances between urban settlements and remote areas is made worse by roads, which are in bad condition and as a result, these conditions make it difficult or expensive for service suppliers to guarantee regular visits and hinder local populations.

- Initial Cost and Investment: Setting up decentralized energy systems, such as solar panels, wind turbines, or microgrids, often requires a significant upfront investment. This can be a barrier for individuals, businesses, or communities with limited financial resources (24).

- Intermittency and Reliability: Many renewable energy sources, such as solar and wind, are intermittent by nature. They depend on weather conditions and time of day, making it challenging to ensure a constant and reliable energy supply without effective energy storage and backup solutions.

- Energy Storage: To mitigate intermittency issues, decentralized systems often require energy storage solutions like batteries. However, the cost of energy storage technologies can be high, and their efficiency and lifespan can vary.

Although centralized grid extension continues to be the main driving force accelerating access to electricity, renewable-based energy solutions have gained ground, the world since the year of 2000 (27). However, it is important to recognize that decentralized renewable energy (DRE) systems are shaping the face of energy access, especially in rural areas of the developing world (ibid). The failure rate of these interventions remains high, suggesting that further work in research and from public institutions is needed to foster for access to electricity in rural areas.

5. Data analysis
A SWOT analysis is a tool that can be used for strategic planning and strategic management by assisting the user to determine the strengths, weaknesses, opportunities and threats of a given endeavor (28). A SWOT analysis was used in this paper to identify the opportunities and challenges related to decentralized energy systems in rural areas of South Africa. The table below indicates the SWOT analysis of an optioning to electrify rural areas by methods of decentralized energy systems or mini-grids.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>The potential to harness a widely available source of clean energy.</td>
<td>Policy must be integrated with implementation strategies for measurable growth.</td>
</tr>
<tr>
<td>Reduced reliance on national energy grid. Localized energy stations are easier to scale-up.</td>
<td>The lack of end-user customer who could generate revenue from rural electrification.</td>
</tr>
<tr>
<td>More optimal use of renewable energy technologies.</td>
<td>The lack of political will remains a barrier in the up scaling of localized energy stations.</td>
</tr>
</tbody>
</table>

**Table 1:** SWOT analysis on the potential of rural electrification using decentralized energy option
The potential of generating new income and increasing tax base.  
The potential to have rural electrification.  
Responding to the critical sustainable development goals.  

| Accessibility into rural areas due to a lack of infrastructure introduces a logistical challenge. In most cases, it can be capital intensive. The skills base needed for the upkeep of the mini grids might be lacking in rural areas and this poses a threat on its maintenance. |

6. Discussion  
To have a functioning energy system, a well-designed framework for regional and local policy for municipalities could offer an opportunity to resolve policy trade-offs and identify potential complementarities among the three objectives of energy security, climate change mitigation, and job creation (29). There is a definite need for a shift in the approach to rural development policy in many countries, and a move away from a model that emphasises sectoral policy and subsidies, to one that is place/area-based and grounded in local conditions and opportunities and that focuses on the competitiveness of rural areas as they would understand their challenges and people better (30). Other factors to be cognisant of when approaching the shift towards a decentralized energy system is that it is critical to entrench energy strategies to the local economic development strategy so that it reflects local potentials and needs (ibid).

To obtain maximum effectiveness and benefits of renewable energy technologies, it is very important to avoid bringing in types of renewable energy on areas that are not well-suited to them. For example, wind power would only be appropriate and efficient in certain areas and, as such, more attention is needed to identify those places rather than adopting policies that somewhat illogically spread decentralized energy projects across the national landscape (29). Also, it is important to focus on reasonably mature technologies such as the production of heat from biomass, small scale hydro, solar and wind. These proven technologies are not likely to experience big jumps in technology that can make recently completed plants instantly obsolete and so in that manner, they would serve as a potential solution to the energy crisis. Ensuring local social acceptance by making clear benefits to local communities through engaging them in the process about the transitioning that will be taking place, is crucial, as local opposition can slow construction and may lead to the failure of subsequent efforts to introduce RE projects. This literature review suggests that putting renewable energy to work in rural areas outweighs the barriers and also decentralized energy systems in rural areas can serve the communities, economy, and environment well. This implies that a new paradigm for rural development should be introduced and applied. By introducing a flexible policy framework that is suited to a particular area, and considering the characteristics and specific needs of hosting economies could be a way to capitalise on the investment in renewable energy in terms of economic development.

7. Conclusion  
As awareness of the importance of clean and reliable energy grows, decentralized energy systems are likely to play an increasingly significant role in transforming rural areas in South Africa and, as such, it becomes increasingly important to investigate how the expansion of decentralized energy systems can be made possible in a sustainable manner.

As part of a PhD study, this paper seeks to suggest some preliminary guidelines on the potential of decentralised energy systems in rural areas such as uMkanyakude district.

This paper reveals key opportunities for decentralized renewable energy systems in rural areas. The
study found that the main advantages of decentralized energy system implementation are linked to the potential to unlock local economic activities, by creating jobs and entrepreneurship opportunities. This new generation of revenue sources brings about a significant impact by fostering economic expansion and improving the livelihoods of people living rural areas. This one action further extends to addressing some of the key Sustainable Development Goals of 2030, which speak to SDG 7 (Affordable and clean energy), 8 (Decent work and economic opportunities) and 11 (sustainable cities and communities). Such interventions not only propose to improve socio-economic conditions of rural communities, but they also attend to another big call of addressing the climate change crisis, towards sustainable and resilient settlements. Through decentralized renewable energy systems, clean and affordable energy can be made possible and thereby leaving no one behind.

While advantages pertaining to decentralized energy systems are evident, the implementation of decentralized energy systems in rural areas presents also challenges, such as technical, financial, and regulatory barriers which need to be overcome to ensure the successful integration of these systems. It is indeed recommended that collaborative efforts among governments, local communities, private sector entities, and non-governmental organizations are made to navigate these challenges and create an enabling environment for decentralized energy adoption. Further studies will look at the practical challenges (including social acceptance) existing in the implementation of such decentralised energy systems in rural areas, with focus on the households’ perceptions and aspirations. In addition, later studies will focus on developing strategies that can be integrated into the local government framework, endorsing rural electrification through decentralised renewable energy systems.

8. REFERENCES


ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa


Evaluating factors that hinder contractors to utilise correct material management system.

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ABSTRACT
Purpose of this paper
The study aims to evaluate factors that hinder contractors to utilise correct material management systems.

Design/methodology/approach
A systematic literature review was expedited to evaluate factors that hinder contractors to utilise correct material management systems in construction industry. This literature search was conducted using the Scopus and google scholar search engines.

Findings
The findings of this study indicate that factors such as: fluctuation in material prices, faulty materials ordering, wrong materials delivery, uncoordinated and disorder in the flow of materials, poor materials storage system, wrong materials delivery, inadequate equipment, regular breakdown of equipment, poor inventory and nonexistence of materials status report, poor materials coordination, voluminous paperwork, delay in materials delivery, ineffective communication among members, delay in procuring construction materials, poor layout of materials handling, multiple handling of materials and poor materials planning hinders contractors to utilise correct material management system.

What is original/value of paper.
This study will contribute to the field of built environment by emphasizing problems that restrict contractors’ ability to manage materials effectively on construction sites.

Keywords: Construction sites; Contractors, Management systems, Materials.
1. INTRODUCTION

Current materials management practices in the construction industry are performed on fragmented basis with unstructured communication and no clear established responsibilities between the parties involved. Therefore stated that the highly fragmentation is caused by the separation of design and construction, lack of coordination and integration between various functional disciplines, poor communication, delay in material ordering and receiving, low productivity, cost and time overrun, conflict and disputes. The primary goal of this study is to identify factors that prevent contractors from using effective material management techniques. One of the major issues in the South African construction industry is the lack of a standardized building materials management system, uncoordinated and disorder in the flow of materials, material payment delays and transportation-related problems which often lead to shortage or lack of material on construction sites. The success of any construction project is dependent on an effective method for managing resources, as this can lead to greater construction project performance as well as organizational growth, success, and survival. Finally, effective building materials management must be based on complete and up-to-date information and implemented utilising a well-thought-out construction materials management method.

2. LITERATURE REVIEW

Currently, the construction material management practice in South Africa is believed to be poorly performed where contractors are ignorant in the effective use of material management practices on site. Poor materials management can often affect the overall construction time, quality and budget. According to, current manual materials management and control procedures are unsatisfactory as they are labour intensive, inaccurate and error prone. These processes include purely traditional procedures with a lot of paperwork. The implication leads to waste and surplus of materials, delays, decrease in productivity and lack of up-to-date and real-time information. Material management challenges are encountered during the execution and completion of any project. The study revealed 4 major factors of ineffective materials management on the construction sites. These include industry corruption, weak enforcement of building codes, material price fluctuation, cashflow problems and high taxes and government fees.

2.1 Industry corruption

Contractors' fraud is a problem in the construction industry, and the fraud can be perpetuated throughout the duration of the construction projects. is of the view that mistakes are made during the pricing of bills of quantities (BOQ) and contractors charge low prices for critical items. They use unrealistic rates and the whole BOQ becomes arithmetically unbalanced. Due to this, materials became a concern and considerably added to project delays.

2.2 Weak enforcement of building codes

Building codes have several applications and are typically used by engineers and architects. Manufacturers, contractors, subcontractors, and safety inspectors who are involved in building industry. All construction activities in the city, region, or nation are required by law to adhere to the building regulations once they have been adopted as legislation by the relevant government body. However, the issue of poor building code enforcement slightly varies from country to country. The administration of building codes typically consists of two sections, the first part includes issues like licenses, permits, fees, inspections, certificates of occupancy and posting of building to indicate permissible live loads and occupant load. The second part ensures that the
appropriate standards are implemented for structural component. However, the effective implementation of Building Codes is dependent on the involvement of stakeholders, performing periodic site inspection and enforcing compliance with the code and related regulations.

2.3 Material price fluctuation

The fluctuation of construction material prices has a significant impact on the construction sector leading to abandonment of construction project before completion. defines project abandonment as having negative environmental implications on society, which is identified as one of the results of fluctuation of construction material prices in South Africa. According to substantial development in the construction industry is dependent on construction material price stability. states that the primary causes of cost variation in construction sector are inadequate estimation of original project costs and underestimation of construction costs by quantity surveyors. Furthermore, costs fluctuate so rapidly that early budget estimates become entirely impractical.

2.4 Cash flow problems

The construction business was found to be significantly impacted by issues of cash flow. Banks are unwilling to help contractors because they lack collateral or sureties that banks can hold onto in the event that payment is late, which makes it difficult for contractors to start and manage projects. Due to their inability to secure cash up front, suppliers are reluctant to provide goods on credit because they worry about not being paid. Additionally, This result to poor credit history. According to, one of the reasons contractors have trouble obtaining materials is that their clients pay late. In addition, contractors use subpar materials to accomplish jobs quickly rather than to the required standards, which leads to structural failure and building collapse.

2.5 High taxes and government fees

noted that if construction companies challenged with high taxes and government fee, it increases the probabilities of avoiding paying taxes; therefore, diminishing the revenue that would have been used by the government for service delivery. It has been argued that Value Added Tax (VAT) is the most effective way of collecting tax. Further stated that VAT is meant to be an efficient tax system in terms of tax turnover since revenue collection goes up, but at the same time, deficits are lowered. However, VAT has a wide range of effects on businesses; it raises both start-up and ongoing operational expenses, and it has a greater impact on construction material. According to, Final Response Document on Taxation Laws Amendment Bill (2017) and Tax Administration Laws Amendment Bill (2017), one of the challenges which prevent contractors from becoming compliant is fear of past contraventions of the law and the implications that may follow should they decide to enter the formal tax system. Further stated that if the government spends the money irresponsibly, people will begin to believe the taxpayers are trying to avoid taxation. revealed that if the government uses the money acquired from taxpayers improperly, contractors will avoid paying taxes, causing the government to spend money on project abandonment due to negligence.

3. METHODOLOGY

The methods used for this study include extensive searching of relevant literatures relating to the study such as Elsevier's Scopus search engine and Google Scholar. According to a thorough literature review on scientific research is the foundation for expanding knowledge of a research field and promotes the development
of significant theories for industrial and academic activities. The search engine utilized keywords such as "Material" OR "management" OR "construction". The search in Scopus identifies 655 total articles as initial (25 August 2023). The initial result was limited to English language, subject area: engineering, environmental science, paper type: conference paper, and journal article, which was performed simultaneously which resulted to 198 articles. Content analysis was performed on the retrieved paper to have the final paper for review such as through topical analysis of the article then followed by abstract and the finding of the paper selected, similarly utilized by 18 Finally, the study used a systematic literature review technique and content analysis. See figure 4.1.

4. IDENTIFICATION OF MATERIAL MANAGEMENT SYSTEMS IN CONSTRUCTION INDUSTRY

A review of relevant literature on the factors influencing material management on building sites was conducted in this study. According to 19; 20, 21 following identified factors that affect material management such as, fluctuation in material prices, faulty materials ordering, wrong materials delivery, uncoordinated and disorder in the flow of materials, poor materials storage system, wrong materials delivery, inadequate equipment, regular breakdown of equipment, poor inventory and nonexistence of materials status report, poor materials

Figure 4.1 Overview of research approach.
coordination, voluminous paperwork, delay in materials delivery, ineffective communication among members, delay in procuring construction materials, poor layout of materials handling, multiple handling of materials and poor materials planning. 21 also identify some of the factors that may affect the management of construction materials; transportation problems, poor materials handling on-site, abuse of materials specification, poor work plan, over-reliance on paperwork and incorrect material delivery. 22 reported that increase in material waste experienced on site and the factors that can hamper materials management efforts are; defective materials (manufacturing faults), damaged materials on-site, poor materials cutting, double handling of materials transport, incomplete instruction on how materials are to be handled, poor handling of materials on site, storage facility located too far from the site, poor contractors' technical staff qualification. A total of 35 significant factors were discovered after reviewing all 65 papers; however, only factors identified in at least two studies are included in Table 1 for further discussion. Table 1 shows numerous elements influencing building material management, each with a corresponding reference. Due to space and word limitations, this study only discusses the top four (4) criteria.

4.1 Discussion of high ranked factors

Faulty materials ordering: 23 defined construction material defects as a deficiency in the construction process be that in design, materials, or workmanship which leads to a failure in some aspect of the structure being built, and that causes damage to a person or property. However, defects in building materials may be apparent during construction, or be manifested as lack of durability after a number of years.

Wrong materials delivery: According to 24 project managers usually order material either too late, leaving the supplier with unclear demand and large material buffers to assure service level, or too early, resulting in buffering at the site. As a result, there is an obvious need for a more interactive management style in which the upcoming phases in a construction project are determined.

Delay in procuring construction materials: Material procurement was discovered to be one of the most important fundamental components that influence the construction of any project 25 A failure in the purchasing process or in overseeing and organising the buying functions could result in over-ordering of materials (wastage problems); over-payment for materials (inadequate administration procedures); loss of benefits (lack of skilled negotiating procedures) and lack of knowledge (when and where the best service/source might be available at any particular time). 26 found that materials procurement plan is one of the best materials management practices for improving productivity in infrastructure projects. 27 confirmed that a materials procurement plan can improve material management in construction projects by minimizing project delays caused by inappropriate building material and negligence.

Poor materials storage system: According to construction law, every part of a construction site must be in good condition, and everyplace of work must be clean. The goal is to maintain an acceptable degree of cleanliness throughout the site 27 also indicates that all service providers must plan, manage, and monitor work so that it is completed safely, with little risk to health and material waste - this includes careful scheduling of material storage. All material must be stored considering the available space, access, powerlines, fire protection, and distances between storerooms and the location where the material will be used. If all of this is not considered, there will be a significant loss of material 27.
<table>
<thead>
<tr>
<th>S/N</th>
<th>Factors affecting material management</th>
<th>sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Faulty materials ordering</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2008); Kasim and Ern (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>2</td>
<td>Incorrect material delivery</td>
<td>Zakeri et al. (2019)</td>
</tr>
<tr>
<td>3</td>
<td>Delay in procuring construction materials</td>
<td>Kazaz et al. (2018); Kasim (2010); Phu and Cho (2019); Kulkarni et al. (2017); Gulghane and Khandve (2015); Jusoh and Kasim (2017)</td>
</tr>
<tr>
<td>4</td>
<td>Poor materials storage system</td>
<td>Gulghane and Khandve (2015); Jusoh and Kasim (2017); Patel and Vyas (2011)</td>
</tr>
<tr>
<td>5</td>
<td>Fluctuation in the prices of materials</td>
<td>Navon and Berkovich (2020); Kasim (2010); Kazaz et al. (2018); Kasim (2010); Rivas et al. (2010); Kasim (2018); Phu and Cho (2019)</td>
</tr>
<tr>
<td>6</td>
<td>Defects of materials from manufacture</td>
<td>Sawalhi and Kass (2012); Phu and Cho (2019); Jusoh and Kasim (2017)</td>
</tr>
<tr>
<td>7</td>
<td>Unavailability of materials prior to the start of actual construction</td>
<td>Kasim (2018); Rivas et al. (2011); Teni (2013)</td>
</tr>
<tr>
<td>8</td>
<td>Late ordering material from the supplier</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2008); Kasim and Ern (2010); Rivas et al. (2011); Kasim (2018); Patel and Vyas (2011); Phu and Cho (2019); Teni (2013)</td>
</tr>
<tr>
<td>9</td>
<td>Uncoordinated and disorder in the flow of materials</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Ern (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>10</td>
<td>Poor materials coordination</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Ern (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>11</td>
<td>Weak building enforcement codes</td>
<td>Kasim and Ern (2010); Rivas et al. (2011); Kasim (2018); Patel and Vyas (2011); Phu and Cho (2019); Teni (2013)</td>
</tr>
<tr>
<td>12</td>
<td>Storage facility located too far from the site</td>
<td>Sawalhi and Kass (2012); Rivas et al. (2011)</td>
</tr>
<tr>
<td>13</td>
<td>Poor work execution and handling plan</td>
<td>Zakeri et al. (2010); Kazaz et al. (2018); Phu and Cho (2019); Jusoh and Kasim (2017); Gulghane and Khandve (2015); Arijeloye and Akinradewo (2016)</td>
</tr>
<tr>
<td>14</td>
<td>Over-dependence on paperwork</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Ern (2010); Rivas et al. (2011); Phu and Cho (2019); Jusoh and Kasim (2017)</td>
</tr>
<tr>
<td>15</td>
<td>High taxes and government fees</td>
<td>Dey (2021); Kasim (2018); Sawalhi and Kass (2012); Patel and Vyas (2011)</td>
</tr>
<tr>
<td>16</td>
<td>Poor inventory control</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Ern (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>17</td>
<td>Cash flow problems</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Ern (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>18</td>
<td>Regular breakdown of equipment</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Em (2010); Rivas et al. (2011)</td>
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<td>19</td>
<td>Poor inventory and non-existence of materials status report</td>
<td>Navon and Berkovich (2020); Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Em (2010); Rivas et al. (2011); Sawalhi and Kass (2012)</td>
</tr>
<tr>
<td>20</td>
<td>Late or delay in materials delivery</td>
<td>Dey (2021); Navon and Berkovich (2020); Aibinu and Odeyinka (2006); Kasim (2018); Kazaz et al. (2018); Kasim and Em (2010); Rivas et al. (2011); Patel and Vyas (2011)</td>
</tr>
<tr>
<td>21</td>
<td>Poor materials planning</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Em (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>22</td>
<td>Ineffective communication among stakeholders</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Em (2010); Rivas et al. (2010); Kulkarni et al. (2017); Patel and Vyas (2011); Jusoh and Kasim (2017).</td>
</tr>
<tr>
<td>23</td>
<td>Delay in procuring construction materials</td>
<td>Navon and Berkovich (2020); Kazaz et al. (20); Kasim and Em (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>24</td>
<td>Poor layout of materials handling</td>
<td>Navon and Berkovich (2006); Kazaz et al. (2018); Kasim and Em (2010); Rivas et al. (2011)</td>
</tr>
<tr>
<td>25</td>
<td>Transportation and logistics problems</td>
<td>Navon and Berkovich (2020); Kazaz et al. (2018); Kasim and Em (2010); Rivas et al. (2011); Teni (2013); Sawalhi and Kass (2012); Gulghane and Khandve (2015)</td>
</tr>
<tr>
<td>26</td>
<td>Theft, pilfering, burglary and vandalism</td>
<td>Patel and Vyas (2011); Phu and Cho (2019); Gulghane and Khandve (2015)</td>
</tr>
<tr>
<td>27</td>
<td>Wrong take-off of materials from contract drawings</td>
<td>Dey (2021); Aibinu and Odeyinka (2006)</td>
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<tr>
<td>28</td>
<td>Improper supervisions leading to loss of materials</td>
<td>Phu and Cho (2019); Gulghane and Khandve (2015)</td>
</tr>
<tr>
<td>29</td>
<td>Materials payment delay problems</td>
<td>Gulghane and Khandve (2015); Arijeloye and Akinradewo (2016)</td>
</tr>
<tr>
<td>30</td>
<td>Poor materials handling on site</td>
<td>Phu and Cho (2019); Gulghane and Khandve (2015); Kulkarni et al. (2017)</td>
</tr>
<tr>
<td>31</td>
<td>Delay due to rejection of materials from quality control team</td>
<td>Kulkarni et al. (2017)</td>
</tr>
<tr>
<td>32</td>
<td>Wastes due to negligence</td>
<td>Zakeri et al. (2021); Jusoh and Kasim (2017)</td>
</tr>
<tr>
<td>33</td>
<td>Rework due to improper quality and mistakes</td>
<td>Sawalhi and Kass (2012)</td>
</tr>
<tr>
<td>34</td>
<td>Delivery of materials at the wrong time</td>
<td>Navon and Berkovich (2020)</td>
</tr>
<tr>
<td>35</td>
<td>Absence of up-to-date information on materials delivery</td>
<td>Navon and Berkovich (2020)</td>
</tr>
</tbody>
</table>

Source: Author 2023
5. **CONCLUSION**

From the study, it can be deduced that a lot of factors hinders contractors to utilise material management system amongst which are; price fluctuation, cash flow problems, poor planning, inventory management concerns, poor procurement handling, materials estimate problems, storage challenges and insecurity, and communication issues were discovered to be the key elements affecting materials management on construction. As a result, the study claims that the dominance of these triggers under-performance in terms of project time, cost, quality, and productivity. This could lead to a loss of revenue and the extinction of future firms. Furthermore, regardless of the size of the construction industry, the causes of poor material management are the same. The authors are of the opinion that abandoning traditional techniques of material management in favour of a technologically oriented material management system is needful. This will ensure an uninterrupted flow of information throughout the organization. This research is restricted to the factors hindering construction material management on construction sites. Further research might be conducted to look into the implementations of material management methods in the construction sector as a whole.

6. **REFERENCES**


The critical success factors for the effective implementation of Post Occupancy Evaluation Practices: A Case Study of RDP buildings in Mpumalanga Province.

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ABSTRACT

Purpose of this paper
The purpose of the paper is to understand the critical success factors required for the effective implementation of post-occupancy evaluation.

Design/methodology/approach
The study adopted a quantitative approach in which a questionnaire survey was expedited in the collection of data, hence data was analysed descriptively and inductively.

Findings
The study indicate that the critical success factors for effective implementation of post occupancy evaluation are participation and commitment, leadership, education and skills, benchmarks and indicators, top management support, availability of resources, POE information management and effective feedback.

Research limitations/implications
The study is limited to RDP building in Mpumalanga Province of South Africa

What is original/value of paper?
This study sought to create awareness on the need to create an enabling environment that necessitates the implementation of POE across the country. In addition, the study recommends that government officials need to
engender a collaborative approach with the occupants of RDP buildings. This will lead to performance improvement in the quest of sustainable delivery of the RDP projects.

**KEYWORDS:** Post occupancy, Evaluation, Building, Housing
1. Introduction

The Housing Act outlines the roles played by local, provincial, and national governments in housing delivery, and it also contains a set of general guidelines that apply to housing development across all levels of government. Construction concerns in RDP homes have been plagued by persistently subpar craftsmanship, which CIDB guidelines could have easily resolved. Some claim that one of the crucial success aspects in resolving this is ensuring that POE has high management support throughout the project to pick out any subpar workmanship. In order for POE to be successful, all the departments and officials responsible for carrying it out must collaborate and participate in the planning process. For the program to continue, all arguments must be handled effectively because doing so will improve future designs and performance. Despite these regulatory bodies and the standards they have developed, there is still debate over the critical success factors for the successful implementation of post-occupancy of RDP structures.

2. Literature Review

The majority of research has demonstrated that there is a severe global scarcity of adequate housing facilities, with the problem getting worse throughout Africa, particularly in South Africa. Poor government policies, poverty, population explosion, and a high unemployment rate are all blamed for the inadequate delivery of subpar housing. Governments tried self-help housing programs before the 1980s, but they didn't work. As a result, efforts to improve housing provision focused on privatizing the responsibility and opening up housing provision to other private market participants. The significance of having and fostering sustainability in housing projects is acknowledged in South Africa. The Act acknowledges the significance of offering housing amenities that improve people's quality of life and guarantee their health. The Act provides a set of general principles that apply to housing development across all levels of government and serves to provide and aid the process. With this in mind, it's crucial to accurately evaluate the planning, building, and habitation of the houses that have been built. This can be proven using a method like post-occupancy evaluation. The evaluation of how well people use occupied, constructed places is known as post-occupancy evaluation (POE). POE is a process of accurately assessing and evaluating buildings after they have been constructed and occupied for some time. They add that this is done to understand how the buildings are performing and how satisfied the occupants are with the buildings. Post-occupancy evaluation (POE) is defined as the study of the effectiveness of human occupants of occupied, designed environments. The idea of POE is not new but was developed in the United Kingdom and has gained acceptance in architectural practice. In the United States, for example, post-occupancy has been credited with showing how satisfied occupants are with buildings. Post-occupancy evaluation has been a tool that the Government has tried to use but questions of its critical success factors have been raised.

For instance, some African countries such as Uganda, Ghana and Madagascar have housing policies that are synonymous with failures. This has prevented most governments from carrying out POE. Plans are being developed for nations such as Nigeria to maximize the use of home mortgages as a means of delivering housing. The country is making use of "traditional methods" to provide housing that involves the sale of land and...
the buyer building the house. Such facilities pose the likelihood of having purchased lands but without any construction taking place. This is because not all people can afford to build houses for themselves and maintain the land.

The provision of housing in most developing countries was guided by policies designed by the World Bank in 1980 and 1990 to promote economic growth and development, known as structural adjustment programmes (SAPs). These policies were designed to help developing countries structurally adjust their economies and markets by allowing the privatisation of services or limiting government responsibility for most social services to increase efficiency and profitability. The World Bank predicted a future breakdown in governance as a result of the extensive provision of services by the public sector at the expense of the private sector. Beneficiaries of Reconstruction and Development Program (RDP) houses face challenges related to RDP houses. One of the major drawbacks of RDP houses is that inferior materials are used in the construction of the houses. Research has shown that roofs, walls, floors, and doors are mostly of poor standard. It is reported that most of them are crumbling, falling, and breaking, not due to external factors, but due to the poor material used.

The foregoing background provided revealed incessant reports of poor methods, non-compliance to standards, and poor materials used to build RDP houses. In this vein, it can be concluded that the industry does not usually focus on design intent for sustainability, rarely do studies undertake post-occupancy evaluations to understand whether design intent has been met. Post-occupancy evaluations (POE) are a practice that helps construction companies and designers gather key feedback from the product's end-user. This helps improve previous weaknesses or design flaws and, in the end, provides the occupants with a better dwelling. POE is regarded as the process in which an evaluation assesses the degree to which the building meets its occupants' needs. This process is undertaken months after the occupants have moved in and made use of the building. This process ensures that there is constant development in design and construction to meet the needs of the occupants. Evaluating the performance of buildings should be considered an iterative process which acts as an ongoing process and extends the upgrading and refurbishment of buildings. However, various research opined that one way to monitor building operations is through Post Occupancy Evaluation (POE). It is with this understanding that the study aimed to investigate the critical success factors for POE practices, especially those delivered through RDP in Mpumalanga Province.

3. Methodology

In addressing the objective, the study adopted a quantitative approach with the use of a questionnaire survey as a data collection instrument. The study population was purposive, this was due to the nature of the data to be collected and they comprise professionals in the Department of Human Settlement in Mpumalanga who are involved in the construction of the RDP building. The breakdown of the number of Professionals within each sub-department and their roles is illustrated below:

<table>
<thead>
<tr>
<th>District</th>
<th>Inspectors</th>
<th>Project manager</th>
<th>Engineer</th>
<th>Chief Engineer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ehlanzeni</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Nkangala</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>
The construction of the housing project is shared by two sub-departments that is the Programme Management Department and the Engineering & Quality Assurance Department. The total population of the departments is 58 and 27 respectively, giving a total of 85. The researcher used total population sampling which is a technique where the researchers choose to examine the whole population because of characteristics or role the participants have. This technique was also utilised because the entire population was relatively small for questionnaire distribution.

The questionnaire consisted of a close-ended questionnaire which ensure that quantitative data is captured adequately. The questionnaire was designed in line with the objectives of the study and a total of 85 questionnaires were distributed. Section A of the questionnaire consisted of the demographic attributes of the participants of the study and section B dealt with the questions from each objective.

The researcher adhered to the research ethics policy as espoused by the Institutional Research Ethics Committee at Durban University of Technology. The researcher also formally requested permission to carry out the study in the Department of Human Settlement in Mpumalanga Province. The researcher ensured that participants were informed formally and asked to freely give their consent to take part in the study. The study also ensured the anonymity of all participants by avoiding requesting individual names on the questionnaires. Data for this study was presented using tables and analysis of data was achieved using appropriate descriptive and inferential statistics. Descriptive statistical analysis extensively measures the characteristics of a study population, whereas inferential statistics draw conclusions or inferences about a population from data sets. The analysis of data was facilitated using Statistical Package for Social Sciences (IBM SPSS Statistics 27). This package analyses data that is imputed on it and creates graphs and themes to discuss. The participants were informed formally and freely gave their consent. In this study, a letter was sent to every participant attached to the questionnaire. Once permission was granted, all potential and actual participants were engaged to outline the implications of participating in the study. This study ensured the anonymity of all participants by avoiding individual names through coding the data provided during data analysis. The researcher observed confidentiality by making sure that the information obtained was not accessible to any unauthorised persons.
4. Discussion of Findings and Analysis

The questionnaire was administered to the respondents and the critical success factors variables were measured. The following are the top critical success factors for the effective implementation of POE: top management support, availability of resources, participation and commitment, effective information feedback, proper management of POE information and access to knowledge. The three least critical success factors that were also identified are leadership, education, and ownership.

**Top Management Support**

![Figure 1.1: Top Management Support](image)

Figure 1.1 presents the responses that respondents gave when asked whether top management support is a critical success factor in the effective implementation of POE in Mpumalanga Province. Two responses from the five given respondents were gathered, that is those that strongly agreed and those that agreed. The majority of the respondents (90%) strongly agreed that top management support is a critical success factor in the effective implementation of POE. The results also show that only 10% of the respondents agreed that top management support is a critical success factor for the effective implementation of POE. The findings, therefore, show that the majority of the respondents strongly agreed that top management support is a critical success factor for the effective implementation of POE.

**Availability of Resources**

![Figure 1.2: Availability of Resources](image)

Figure 1.2 presents the responses given by respondents when asked whether the availability of resources is a critical success factor for the effective implementation of POE. The findings show that 80% strongly agreed that is a critical success factor, while 19% agreed and 1% remained neutral. The findings, therefore, show that the majority of the respondents (80%) strongly agreed that the availability of resources is a critical success factor that leads to the effective implementation of POE in Mpumalanga Province. Commenting on integrated development plans highlights that funding by the Provincial Government should always be in place.
if the programmes or initiatives they wish to achieve are to be realised. This corroborates with those who also argue that there is the need to prioritise and allocate enough resources if government projects are to be a success. The findings of this study corroborate with these studies when we look at POE in Mpumalanga Province, as they show that the availability of resources is one of the key success factors of the POE. The Government needs to allocate enough resources and ensure that proper budgets are allocated especially for the implementation of projects. POE is one such project that needs enough resources for the departments and officials working on this to effectively do their job. The study concludes that funding is key as lack of it causes the ineffectiveness of POE to occur. It can thus be concluded that government funding is a key issue that needs to be considered when discussing post-occupancy evaluation, as such evaluations need to be financially oiled to drive them well. The resources also need to be for the evaluation process from start to finish for the program to be effective.

**Participation and Commitment**

![Participation and Commitment Diagram](image)

Figure 1.3: Participation and Commitment

Figure 1.3 shows the responses that were gathered from respondents when they were asked if participation and commitment are critical success factors for the effective implementation of POE in Mpumalanga Province. The majority of the respondents 71% and 29% strongly agreed and agreed that participation and commitment are critical success factors for the effective implementation of POE. Figure 1.3 also show only these two responses, and it can be concluded that participation and commitment is a critical success factor for the effective implementation of POE in the Mpumalanga Province. This matches what is argued by saying that bottom-up strategies should be developed before housing projects are started. According to, those who develop these projects should ensure that community members are engaged, and this can be through outreach programmes, sending letters to inform possible occupants about the decisions and plans they have and consulting with them. notes that beneficiaries are usually informed at later stages, however, this is a problem. This is because having consultation during the process or later stages of the building does not capture the needs and concerns of the beneficiaries well. This results in little room left for the clients and occupants to demand change in the housing schemes done already during the implementation of these projects. contend that actively engaging citizens or potential beneficiaries increase ownership of the projects to follow. They further show that when a project is about to be launched as long as it has a bearing on the public they have to be consulted. When this is done it ensures that they actively participate and are open to sharing their ideas that can positively assist the project.
Effective flow of feedback

Figure 1.4 presents the responses that respondents gave when asked if the effective flow of feedback is a critical success factor for the effective implementation of POE in Mpumalanga Province. The majority of the respondents (60%) agreed that the effective flow of feedback is a critical success factor for the effective implementation of POE. The findings of this study also reveal that 40% of the respondents strongly agreed with the same question and no other responses were gathered. The results conclude that the majority of the respondents agreed that the effective flow of feedback is a critical success factor for the effective implementation of POE in Mpumalanga Province. Without effective feedback areas that require improvements are not communicated. 5 argue that feedback is key in POE as it informs the construction companies and officials involved on the areas that require improvement. 6 also takes the same position by arguing that the process ensures that there is constant development in the design and construction to meet the needs of the occupants.

Indicators and Benchmarks
Figure 1.5 presents the responses that respondents gave when asked if indicators and benchmarks are critical success factors for the effective implementation of POE in Mpumalanga Province. The majority of the respondents (71%) strongly agreed that indicators and benchmarks are critical success factors for the effective implementation of POE. The findings of this study also reveal that 28% of the respondents agreed with the same question while 1% remained neutral when asked the question. The finding, therefore, shows that the majority of the respondents strongly agreed that indicators and benchmarks are critical success factors for the implementation of POE in Mpumalanga.

Access to Knowledge

Figure 1.6 above shows a graph that presents the responses that respondents gave when asked if access to knowledge is a critical success factor in the effective implementation of POE in Mpumalanga Province. 60% of the respondents strongly agreed that access to knowledge is a key factor. 35% of the respondents agreed to the same question while 5% remained neutral on the question. The study findings on this question show that the majority of the participants see access to knowledge as a critical success factor for the effective implementation of POE in Mpumalanga Province. Access to knowledge was also noted and this is a critical success factor for participation and engagement to also take place. This is because when knowledge flows well everyone gets to know what is to be done and also contributes to ideas that benefit POE.

This matches what 17 argues by saying that bottom-up strategies should be developed before housing projects are started. According to 17, those who develop these projects should ensure that community members are engaged, and this can be through outreach programmes, sending letters to inform possible occupants about the decisions and plans they have and consulting with them. 18 notes that beneficiaries are usually informed at later stages, however, this is a problem. This is because having consultation during the process or later stages of the building does not capture the needs and concerns of the beneficiaries well. This results in little room left for the clients and occupants to demand change in the housing schemes done already during the implementation of these projects. Mail and Guardian (2016) has reported that when beneficiaries are not informed or when a top-down approach is adopted problems are likely to result later in the process. Protests that occur are a result of such a stance on having passive involvement and this affects occupant satisfaction and design in the initial
stages of the projects. This shows that several issues are linked, and all these contribute to effective post-occupancy evaluations, which are community engagement, design, and ownership. Failure in one of these elements can render the entire process futile.

Skills

Figure 1.7 presents the responses that were gathered from respondents when they were having skills is a critical success factor for the effective implementation of POE in Mpumalanga Province. The majority of the respondents 60% and 35% strongly agreed and agreed that skills are required to have effective implementation of POE respectively. Moreover, 5% of the respondents remained neutral when asked the question. The findings as presented in Figure 10 also show that the majority of respondents (60%) see skills as a critical success factor for the effective implementation of POE in Mpumalanga Province.

Education and Attitude

Figure 1.8 shows the responses participants gave when asked if education and attitude are critical success factors in the effective implementation of POE in Mpumalanga Province. The research finding shows that the majority of the participants (58%) strongly agreed that it is a barrier while 39% pointed out that they agree that education and attitude are critical success factors for the effective implementation of POE. Additionally, the graph above also shows that 4% had no comment on the question and therefore remained neutral. The findings for this question, show that the majority of the respondents agreed that education and attitude is a critical success factors for the effective implementation of POE in Mpumalanga Province.
Knowledge

Figure 1.9 shows a graph that presents responses participants gave concerning knowledge as a critical success factor in the effective implementation of POE in Mpumalanga Province. The research found that 54% of the respondents strongly agreed that it is a critical success factor while 45% of the respondents pointed out that they agreed that it is a critical success factor. Only 1% of the respondents remained neutral when asked the same question. The study findings for this question, show that the majority of the respondents strongly agreed that knowledge is a critical success factor for the effective implementation of POE in Mpumalanga Province.

Managing POE Information

Figure 1.10 shows the responses that were gathered from respondents when they were asked if managing POE information is a critical success factor for the effective implementation of POE in Mpumalanga Province. The majority of the respondents 53% strongly agreed while 48% of the respondents agreed that managing POE information is a critical success factor for the effective implementation of POE in the Province. The findings, therefore, show that the majority of the respondents strongly agreed that managing POE information is a critical success factor for the implementation of POE in the Mpumalanga Province. 23 argue that many researchers have pointed out that POE has over the years been used as a tool for documenting activities in building projects. When previous evaluations and documents are not made available it negatively affects the entire process or slows it. Preiser (1995) cited in 24 also points out the importance of availing documents to those conducting the POE. Previous and other documentation serves as a guide that informs those conducting the POE process. Indicators and benchmarks can also be derived from these documents thus making documents inaccessible needs to be encouraged to ensure POE success.
Leadership

The graph above (Figure 1.11) shows the responses on the view respondents had on leadership as a critical success factor in the implementation of POE in Mpumalanga Province. Most of the participants 44% strongly agreed that effective leadership is a critical success factor in the implementation of POE while 36% of the respondents also agreed. However, 20% of the respondents remained neutral and thus could neither confirm nor deny the statement. The findings from Figure 6 show that the majority of the respondents did see leadership as a critical success factor that leads to effective implementation of POE if those who strongly agreed and agreed are combined.

Ownership

Figure 1.12 presents the responses that respondents gave when asked if ownership is a critical success factor for the effective implementation of POE in Mpumalanga Province. 35% of the respondents disagreed that ownership is a critical success factor for the effective implementation of POE. 28% of the respondents agreed with the same question while 20% remained neutral. Only, 18% of the respondents strongly agreed that ownership is a critical success factor for the effective implementation of POE. Community engagement also increases ownership in development projects. They argue that ownership is one of the key areas that emerge from effective participation in development projects to be conducted in a province. This is because the people who have been consulted can state their needs, concerns, or worries and if these are captured ownership of the project is enhanced. They further show that when a project is about to be launched as long as it has a bearing on the public they have to be consulted. When this is done it ensures that they actively participate and are open to sharing their ideas that can positively assist the project. The study found that ownership of the buildings, education attitudes and leadership were the least critical success factors. The study found that when the above most critical success factors are available effective implementation of POE will be achieved.
5. Conclusion
From the study, it can be deduced that for the effective implementation of post-occupancy evaluation in RDP buildings the participation, commitment, and collaboration of all the stakeholders should be encouraged, and occupants should be made part of these. The occupants of the RDP buildings should not be excluded from the process participation as this is where their ideas and contributions can be raised. Ensuring participation and having feedback as was noted in the findings above creates a sense of ownership of the project and enables ideas and concerns to be freely given. It is also important to ensure that the programme is supported by top management and that resources are made available. In carrying out POE, municipal authorities have to ensure that these success factors are discussed in the meetings and find ways to enhance them. The findings of the study are similar to previous studies, and it also adds a few key issues. The study recommends that government officials need to ensure active participation and discussion with occupants of RDP buildings as this will ensure positive feedback and will engender a win-win situation across parties in the quest for sustainable delivery of RDP projects.

6. References


Small and Micro Enterprise Contractors Response to Subcontracting Policy: A Resource-Based View Perspective

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ABSTRACT

Purpose
Small and medium enterprises [SMEs]' participation in public construction procurement depends on the firm's ability to respond successfully to tenders. With an enabling external environment to encourage SMEs' participation in public procurement through the subcontracting policy, SME firms' capabilities to utilise acquired resources is key for their participation in public tenders. The study aimed to assess Resource-Based View's influence on SME firms to participate in public construction procurement successfully.

Design/methodology/approach
An explanatory mixed-method design was employed to collect quantitative and qualitative data. Quantitative data using a questionnaire was collected from 80 randomly selected SME firms in the Zambian construction industry based in Lusaka, Zambia. Follow-up qualitative data was collected from purposively selected 04 participants working in public procurement institutions. Survey data was analysed using descriptive frequencies, mean and standard deviation statistics. Thematic analysis was used to analyse qualitative data to explain the quantitative results in detail.

Findings
The findings indicate that procedural capability was found to significantly influence SME firms’ response to successfully participate in public construction procurement. SME firms’ decision to tender for construction projects was based on the firm’s ability to manage the tendering process.
Practical implications
The resource-based view is critical to explain SME firm’s sustained competitive advantage in public construction procurement based on the firm’s acquisition and utilisation of necessary capabilities.

Original/value
The findings will help validate empirical evidence of the Resource-Based View's influence on SMEs' successful participation in public construction procurement.
1.0 INTRODUCTION

Small, Micro and Medium Enterprises [SMMEs] play an essential role in economic development and social advancement in most countries, particularly in developing countries (Ancarani, Di Mauro, Hartley and Tátrai, 2019; Hoekman and Tas, 2022; World Bank, 2020). SMMEs account for most businesses worldwide and contribute to job creation (Demirel and Danisman, 2019). They represent about 90% of businesses, contribute more than 60% of employment worldwide and up to 40% of the global Gross Domestic Product [GDP] (Dabic, Maley, Dana, Novak, Pellegrini and Caputo, 2019; International Labour Organisation [ILO], 2018). Four economic potentials and contributions of SMMEs are highlighted in the literature. Firstly, the SME sector comprises the vast majority of firms in many economies in absolute numbers (World Bank, 2020). Secondly, SMMEs contribute by providing the most significant employment in the economy in terms of numbers (ILO, 2018; Wozniak, Duda, Gasior and Bernat, 2019). Thirdly, SMMEs contribute in terms of increased outputs, taxation contribution and the resultant reduction in the dependency ratio (Cardoza, Fornes, Farber, Gonzalez Duarte and Ruiz Gutierrez, 2015). Fourthly, the SME sector is essential in its contribution to innovation and regional development (De Marco, Martelli and Di Minin, 2020). Furthermore, SMMEs promote inclusive and sustainable economic growth and decent work for all (Kidalov and Snider, 2017).

Globally, the scale of the construction market has grown from USD 9.5 trillion in 2014 to USD 11.4 trillion in 2019 (Global Opportunity Report, 2018). With the global construction output projected to reach USD 17.5 trillion in 2030 (Global Construction Outlook [GCO], 2018). Public procurement construction represents a significant proportion of construction procurement in global economy (The World Bank, 2020). It is a vital channel through which the projected 85% construction output growth will be achieved (Kohler and Dimancesco, 2020). Scholarly debate has contributed to the appropriateness of public procurement for SMMEs and attempt to present a more realistic expectation about the scope and extent of their engagement with the process (Reijonen, Tammi and Saastamoinen, 2016).

The debate centres to main issues; firstly, the sectors that are more suited to SMMEs supply and secondly, the position of the SMMEs in the supply chain (Flynn, 2018). According to Loader (2015), in relation to the type of supply, evidence suggests that SMMEs are most likely to be involved in the supply of routine products and also may be suited to supplying smaller, niche markets. Specific sector where SMMEs are seen to have a stronger presence include facilities management, construction consultancy and social services (Hwang, Ngo and Teo, 2022).

The construction sector in Zambia is led by the demand by mining industry, shopping centres, infrastructure development, residential buildings and offices (GRZ-Ministry of Finance and National Planning [7th NDP]) (GRZ-Ministry of Finance and National Planning, 2017). The growth in real and construction sectors led to direct and spill-over employment effects on the broader economy (Aigbavboa, Aghimien, Oke and Mabasa, 2018). The industry predominantly comprises small, micro and medium enterprises [SMMEs] (National Council for Construction, 2020). ZCI is driven by an increase in public and private sector investment in infrastructural development investment (GRZ-MNDP, 2017). SMMEs in the ZCI are faced with fierce competition from both local and foreign firms for construction projects, hence the high rate of failure to survive by the SMMEs (Tayeh, Alaloul and Muhaiseen, 2019).

The introduction of the subcontracting policy in the Zambian Public Procurement is aimed at mitigating the subcontracting challenges experienced by the small, micro and medium scale contractors in accessing subcontracting contracts on public sector projects awarded to foreign based construction firms operating in the Zambian construction industry [ZCI] (GRZ-National Assembly, 2020). Though there has been a government-enabling policy for SME participation in public construction procurement, there is need for the SME capabilities to compete in a competitive public construction market. This study investigates the SME contractors' response to the subcontracting policy's introduction in the ZCI through a Resource-Based View perspective.
2.0 LITERATURE REVIEW

2.1 Public Procurement as Policy Tool

Public procurement has been used as a government policy tool for strategic and systematic potential beyond the mere act of purchasing (Fourie and Malan, 2020). In particular, public procurement has increasingly been perceived as a policy tool to promote what are arguably secondary goals (Kristensen, Mosgaard and Remmen, 2021). Such as promoting socio-economic policies to the primary aim of procurement, which is the acquisition of goods and services (Fourie and Malan, 2020). Furthermore, the role and potential of public procurement in delivering desired policy outcomes in society has made it attractive to governments which seek to achieve multiple social and economic policy objectives (Loosemore and Reid, 2019). Within this “extended policy environment, it acts as a vehicle for achieving wider socio-economic goals such as sustainability, supporting SMMEs, encouraging innovation and aiding minority-owned businesses (Troje, 2019).

It is argued that a well-functioning economy provides employment opportunities for its citizen, thriving business activities including technological innovation and multi-sectoral engagement (Fourie and Malan, 2020). This is achieved by enhancing SMES participation in public procurement, as public procurement plays a dual role for SMMEs (World Bank, 2020). It is both a significant source of business as well as a potential for the development of SMMEs through creating and implementing enabling policies for their participation and growth (Botha, Smulders, Combrink and Meiring, 2021). Four potential outcome areas have been identified when public procurement is used as a policy instrument to influence SMEs participation and growth in the local economy (Ancarani et al., 2019). These include the promotion of entrepreneurship and skills, improving SMEs' market access, improving SMEs' growth potential, and strengthening dialogue and consultation with SMEs stakeholders (Nguyen and Trinh, 2020).

Preferential procurement enables governments to give preference to minority enterprises in public procurement. It is an instrument used to promote disadvantaged and emerging firms access to government contracts and improve their ability to participate in public tenders (Troje, 2019). Preferential procurement enables governments to create social value through employment creation and foster societal goals. This results in the inclusion of SMEs in the public sector supply chain (Sian and Smyth, 2022). Methods of preferential procurement include set-aside schemes allowing only enterprises with prescribed characteristics to compete for contracts of portion reserved for their execution (Anthony, 2019). Other preferential procurement methods include preferencing, which limits the number of contractors invited to tender based on set qualification; indirect, designed to specific contract conditions; and procurement processes to benefit particular contractors (Watermeyer, 2003).

2.2 Resource-Based View [RBV] Theory

Resource-Based View [RBV] theory of the firm is recognised as the most influential framework for understanding strategic management and is used to describe and operationalise constructs of competitive advantage (Barney, 1991). Resource-Based View has been one of the key theories in entrepreneurship largely because it explains the firm’s performance in terms of bundles of resources owned or controlled by the firm (Barney, 1991). Further, because of SME firms’ unique characteristics, RBV theory is a suitable theory employed to frame and examine the role of resources in SME firms as a source of competitive advantage in the market (Flynn, 2017).

RBV theory’s defines resources as all assets, capabilities, organisational routines and informational attributes of the firm that enable it to compete, as such, access to resources is central to the success of a firm (Barney, 1991). There are two underpinning assumptions of RBV theory (Johnsen and Caniato, 2022). The first is that quantity and quality of resources owned or controlled by firms vary within and across sectors, implying that firms are heterogeneous as to their resource base. (Barney, 1991). The second is that the various resource types, particularly capabilities, are not always tradeable and can be organisational or context specific. Thus, the
competitive advantage they yield for the firm becomes difficult for rivals to imitate which can eventually lead to a sustained competitive advantage (Flynn, 2017).

The key to competitive advantage is for SME firms to be able to sustain the advantages gained from superior utilisation of the internal resources they control (Goh and Loosemore, 2017). Resources, capability advantages and understanding the sources of competitive advantage is critical to SME firms sustained success in a given market environment (Ghasemaghaei, 2019). RBV theory explains how valuable, rarity (heterogeneity), imperfectly imitable [immobility], and not substitutable in firm-specific resources and capabilities lead to sustained competitive advantage (Helfat and Peteraf, 2015). However, these characteristics will only be critical when the following two prerequisite conditions exist: heterogeneity and imperfect mobility of strategic resources among competing firms (Barney, 1991).

2.3 SME Firm’s Resource and Capability Base

Resources and capabilities can be viewed as bundles of tangible and intangible assets, a firm’s management skills, organisational processes and routines, and the information and knowledge it controls, including employees who are strategically important to the firm (Barney, 1991). A Resource should have these four key attributes; rare [unique] and valuable [worth something], imperfectly mobile [cannot be easily sold or traded] and non-substitutable [is not easily copied] for firms to exploit opportunities, neutralise threats in the business environment and be a source of competitive advantage (Burvill, Jones-Evans and Rowlands, 2018). This prevents competing SME firms from implementing the same strategy, thereby creating a pure competitive market. Imperfectly imitable resources will ensure that competitors cannot obtain valuable and rare resources in the firm (Barney, 1991).

Two types of capabilities specific to public procurement include procedural capability and relational capability. Procedural capability signifies the ability to manage formal, regulated aspects of tendering and contract administration (Flynn, 2017). The second one is relational in form which is about firms engaging with public buyers and promoting themselves as value-adding supply partners (Flynn and Davis, 2017). However, possessing skills and knowledge about the business and the business environment the firm is operating in is not a sufficient source of competitive advantage where the SME firm fails to implement these resources correctly (Goh and Loosemore, 2017). Lukovszki et al. (2021) posit that as SMEs rely on extremely scarce resources, effective use of resources and capabilities is key to gaining competitive advantages. Sustainable competitive advantage can only be created when the firm fully realises the benefit of the resources they control (Barney, 1991).

It is worthy to note that there is a lack of an adequate definition of resources for RBV studies which has caused confusion as to what researchers mean by key terminologies (Yang et al., 2015). In this study, resources are defined as anything tangible or intangible that SME firms can use to participate and grow in public procurement in the ZCI successfully. Capabilities are defined as the SME firm’s ability to assemble, integrate and use public procurement tendering resources to successfully participate in public procurement within the ZCI (Yang et al., 2015).

2.4 SMEs’ Application of Resource-Based View [RBV] in Public Construction Procurement

Resources and capabilities can be viewed as bundles of tangible and intangible assets, a firm’s management skills, its organisational processes and routines, and the information and knowledge it controls, including employees who are strategically important to the firm (Barney, 1991). A Resource should have these four key attributes; rare [unique] and valuable [worth something], imperfectly mobile [cannot be easily sold or traded] and non-substitutable [is not easily copied] for firms to exploit opportunities, neutralise threats in the business environment and be a source of competitive advantage (Burvill, Jones-Evans and Rowlands, 2018). This prevents competing SME firms from implementing the same strategy, thereby creating a pure competitive
market. Imperfectly imitable resources will ensure that competitors cannot obtain valuable and rare resources in the firm (Barney, 1991). Resource-Based View gives insight for SME contractors involvement in public procurement in terms of varying resources and capabilities necessary of SME firms competitive advantage in public procurement (Flynn, 2017). The resources have a bearing on the ability of the SME firm to compete efficiently and effectively in public procurement (Barney, 1991). The following are the specific areas on how the theory was used in the present study.

a) Identify SME firms' internal resources for competitive advantage

An important aspect of RBV is its simplicity and focus of firm performance and the ability to explain how SME firm-level [sustained] competitive advantage arises from the firm’s internal resources and strategic application of the resources (Aksoy, 2017; Beamish and Chakravarty, 2021; Savino and Shafiq, 2018). RBV enables scholars to critically evaluate and obtain a far greater understanding of a SME firm’s strengths and weaknesses than conventional SWOT [strengths, weaknesses, opportunities, and threats] analysis does (Burvill et al., 2018). Fundamentals of RBV theory to this study, is how SME firms can transform their internal resources and strategic application of the resources to determine SME performance and sustain their competitive advantage in the market (Roostika, 2019). More recently, it has been argued that resources do not necessarily need to be rare but can be quite ordinary and still provide a SME firm with competitive advantage (Ferreira, Serra, Costa and Almeida, 2015). Drawing from RBV, ability to prepare and submit responsive bid, availability of finances, technical know-how and firm’s competence using electronic government procurement system, are some of the critical firm capabilities and resources for SME contractors necessary for successful participation in public procurement in the ZCI (Barney 1991).

b) Determine SME firm learning needs and abilities

Within the context of RBV, the firms’ ability to learn and change in a rapidly changing environment are among the most important capabilities a firm can possess (Roostika, 2019). RBV has important implications for studying participation and success of SME contractors in public procurement (Flynn, 2017). Specific training of SME contractors in entrepreneurial skills can enable firms to gain sustainable competitive advantage (SCA) over competitors (Burvill et al., 2018). The ability for firms to translate acquired knowledge in entrepreneurial skills might develop a substantial edge over less skilled competitors, keep pace with competitors and prove to be inimitable (Beamish and Chakravarty, 2021). Based on RBV perspective, firms’ skill sets such as tendering, preparation of bids, marketing, managerial and technical skills enhance the firm’s performance and act as potential source of sustainable competitive advantage (Takata, 2016).

3.0 METHODOLOGY

The study employed explanatory sequential mixed method design to assess the resource-based view's influence on SME contractors to participate in public construction procurement. Explanatory sequential design involved a two-phase distinct data collection (Teddie and Tashakkori, 2011). In the first phase, quantitative data was collected from 80 randomly selected SME contractors in Grades 5 and 6 operating in Lusaka province. National Council for Construction [NCC] classifies contractors from Grade 1, the largest category to Grade 6, the smallest grade (National Council for Construction [NCC], 2020). Grade 5 and 6 contractors were selected as they represent the broader targeted SME contractors’ population in its characteristics. The sought to investigate the influence of resources on the firm’s responses to public construction tenders among the category of SME contractors in the Zambian Construction Industry [ZCI]. The analysed quantitative results informed the follow-up qualitative data collection from 5 purposively selected participants to help explain the emerging quantitative results in detail. The point of saturation of the information obtained was reached at the fifth [5th] participant (Bryman and Bell, 2019; Creswell and Plano-Clark, 2018). In explanatory sequential
design, the quantitative sample size is usually larger than that of the qualitative phase (Teddlie and Tashakkori, 2011). This is because the quantitative results aim to provide the statistical power for generalizability. And the qualitative sample provide thematic analysis to the quantitative results. (Creswell and Plano-Clark, 2018).

Data analysis consisted of analytic techniques applied to quantitative and qualitative data (Creswell, 2015). The overall intent of the explanatory sequential design was to have a qualitative stand explain in more detail the initial quantitative results (Creswell and Plano-Clark, 2018). Quantitative data analysis proceeded from descriptive analysis, including the mean and standard deviation [SD], to inferential statistical tests (Creswell and Plano-Clark, 2018). Thematic analysis in the qualitative phase helped to explain the quantitative results (Teddlie and Tashakkori, 2011).

Specific quantitative cases were examined, isolated and informed the qualitative design. Themes in results from the qualitative design were identified, which then were used to explain quantitative results (Teddlie and Tashakkori, 2011). After reviewing both sets, data was consolidated to create new variables that were further analysed (Creswell and Plano-Clark, 2018). This was achieved by employing qualitative themes and codes to provide additional insight and meanings behind the findings of the quantitative specific results, an approach consistent with explanatory sequential design (Ivankova, 2014).

4.0 PRESENTATION OF RESULTS

4.1 Respondents Profile

The respondents profile shown in Table 4.1 shows that most SME firms [68%] are registered in the NCC lowest grade 6, while 32% of the SME firms are registered in grade 5. The sample shows that most [45%] SME firms construction experience ranging between 4 to 6 years. The nature of projects that the respondent firms were involved in include housing [40%], school and health infrastructure at 10% and 20% respectively, and office buildings at 15%.

Respondents in managerial position were the majority [55%], followed by firm owners/ directors [30%]. The analysis of the data shows that respondents with 16 years of experience and above to the least at 13%, 11-15 years’ experience at 30%. While those with 1-5 years’ experience and 6-10 years’ experience were at 15% and 42% respectively.

<table>
<thead>
<tr>
<th>Table 4.1 Respondents Profile.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
</tr>
<tr>
<td>Firm’s NCC Registration</td>
</tr>
<tr>
<td>Grade 6</td>
</tr>
<tr>
<td>Grade 5</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Firm’s Construction Experience</td>
</tr>
<tr>
<td>1-3 years</td>
</tr>
<tr>
<td>4-6 years</td>
</tr>
<tr>
<td>7-10 years</td>
</tr>
<tr>
<td>Above 10 years</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Nature of Projects Involved</td>
</tr>
<tr>
<td>Housing</td>
</tr>
<tr>
<td>School Infrastructure</td>
</tr>
</tbody>
</table>
4.2 Participants Profile

The participants profile displayed in Table 4.2 shows that 40% of the participants are from government ministries. Parastatal, government regulatory authority and SME firms each had 20%. The sample comprises of managers [20%], principal officers [40%], senior officers [20%] and firm owner/directors [20%]. About 60% of the participants have work experience ranging between 11 and 15 years. Participants with 5-10 years and above 16 years’ experience in public construction procurement each were at 20%.

Table 4.2 Participants Profile.

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Institution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government Ministry</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Parastatal</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Government Regulatory Authority</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>SME Firm</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td><strong>Position</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manager</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Principal officer - Procurement/technical</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Senior Officer - Quantity surveyor/Project manager</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Firm owner/director</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td><strong>Work Experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-10 years</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>11-15 years</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>Above 16 years</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>
4.3 RBV’s influence on SME firms’ Response to Participate in Public Construction Procurement

The participants were asked to rate their level of agreement with the resource-based view capabilities that influence their response to participate in public construction procurement. Table 4.3 shows the resource-based view capabilities that influence SME firms’ response to participate in public construction procurement. Under procedural capability, knowledge of bid preparation had a mean score of 3.90, ability to read tender instruction in bid documents [3.87], qualified technical personnel required to prepare bid document had a mean score of 3.70. The mean scores lie within the 4.49 ≥ x ≥ 3.50 range, indicating a considerable influence on SME firms’ response to participate in public construction procurement. Access to finance for bid submission and experience in works of similar in nature had mean values of 3.74 and 3.50 respectively, while access to machinery for bid submission had a mean score of 3.36.

With regards to relational capability, good relationship with procurement officials had a mean score of 3.03, distribution of firm profile to procurement entities [2.95], while networking and reputation [2.74]. The mean values lie within the 349 ≥ x ≥ 2.50 range, indicating less influence on SMEs firms’ response to participate in public construction procurement. Promoting the firm through social media and attending trade fairs to market the firm had mean values of 2.47 and 2.43, respectively.

Table 4.3 Resource-Based View Influence on SME Firms’ Response to Participate in Public Construction Procurement.

<table>
<thead>
<tr>
<th>Resource-Based View</th>
<th>Mean</th>
<th>SD</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural capability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of bid preparation</td>
<td>3.90</td>
<td>.975</td>
<td>1</td>
</tr>
<tr>
<td>Ability to read tender instructions in bid document</td>
<td>3.87</td>
<td>.989</td>
<td>2</td>
</tr>
<tr>
<td>Qualified technical personnel required to prepare bid document</td>
<td>3.70</td>
<td>.906</td>
<td>3</td>
</tr>
<tr>
<td>Access to finances for bid submission</td>
<td>3.74</td>
<td>1.03</td>
<td>4</td>
</tr>
<tr>
<td>Experience in works of similar in nature</td>
<td>3.50</td>
<td>.992</td>
<td>5</td>
</tr>
<tr>
<td>Access to machinery for bid submission</td>
<td>3.36</td>
<td>.986</td>
<td>6</td>
</tr>
<tr>
<td>Relational capability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good relationship with procurement officials</td>
<td>3.03</td>
<td>1.036</td>
<td>7</td>
</tr>
<tr>
<td>Distribution of firm profile to procuring entities</td>
<td>2.95</td>
<td>1.230</td>
<td>8</td>
</tr>
<tr>
<td>Networking and reputation</td>
<td>2.74</td>
<td>1.125</td>
<td>9</td>
</tr>
<tr>
<td>Promoting the firm through social media</td>
<td>2.47</td>
<td>1.070</td>
<td>10</td>
</tr>
<tr>
<td>Attending trade fairs to market the firm</td>
<td>2.43</td>
<td>1.011</td>
<td>11</td>
</tr>
</tbody>
</table>

4.4 Role of Procedural and Relational Capabilities in influencing SME firms’ Response to Participate in Public Construction Procurement

The participants indicated procedural capability had the largest influence on SME firms to participate in public construction procurement.
construction procurement, as the ability to posse and utilise specific tendering capabilities was key to participate in public tenders.

“... SME firms need the ability to know how to prepare a responsive bid, otherwise their bids will be disqualified due to non-adherence to the stipulate instructions in the solicitation document...”

“...You see, that the mistake SME contractors make, they think that if they have a relation with the procurement officers, they will win the tender. But the tender is won by submitting a responsive bid which requires knowledge people to put together...”

“...chances of winning a tender requires that you show proof of having done some similar works.... also you should have some basic equipment required to execute the project..., all these require you to have some considerable finances to put together the bid...”

5.0 DISCUSSION AND IMPLICATION

The study assessed two types of resource-based view capabilities: procedural capability and relational capability specific to public procurement. RBV-V theory examines the role of specific resources firms should possess and utilise to achieve desired results a competitive public construction procurement market environment (Yang, Xun and He, 2015). As such, the study results indicate that specific procedural capabilities play a significant role in SME contractors’ responses to effectively participate in public construction procurement.

The results show that procedural capability had the largest influence on SME contractors’ response to participate in public construction procurement. Procedural capabilities such as the knowledge to prepare a responsive bid, qualified technical personnel and access to machinery and finances were found to largely influence the SME firms to participate in public construction procurement. The findings collaborate with the study by Huggins and Weir (2012) which indicate procedural capability elements such as the firm’s ability to manage formal, regulated aspects of tendering are important for the firm’s competitive advantage in public construction procurement. Lukovszki et al., (2021) posit that SME firms’ competitive advantage in public construction procurement is premised on the firms acquired and utilisation of procedural capabilities. According to RBV theory, access to procedural capabilities are important for SME firm’s success in a public construction procurement system (Flynn, 2017; Barney, 1991).

The findings indicated that relational capability was not found to have much influence on SME contractors’ decision to participate in public construction procurement. Relational capabilities though important, has less influence on the successful participation of SME contractors in public construction procurement. Relational capabilities entail creating an awareness of the firm’s presence and services to the buying entities. The findings agree with those reported by Flynn and Davis (2017) that relational capabilities are important for firms to engage with public buyers and promoting the firm’s services in the supply chain. Relational capabilities are helpful in stances where the buying entities intend to shortlist firms to participate in a tender. Even in such an instance, ultimately, procedural capabilities will be necessary for the SME firm to successfully participate and submit a responsive bid in the selective tender.

The study findings have theoretical and practical implication. Theoretically, the findings support resource-based view theory that firms have to acquire and effective utilise specific capabilities in a competitive public construction procurement market. Practically, procedural capability is important to influence emerging SME contractors to participate in an enabling subcontracting policy environment.

Procedural capabilities will enable SME firms participate in public construction projects through the enabling environment created by the 20 percent subcontracting policy on large government projects.

6.0 CONCLUSION AND RECOMMENDATIONS

The paper examined SME contractor’s response to subcontracting policy through procedural capability and relational capability, resource-based view capabilities. The findings reveal that procedural capability has an
influence on SME contractor’s decision to participate in public construction procurement. However, relational capabilities are important to have relationship with public buyers and market the firm’s services. This gives the public buyers an opportunity to invite firms for selective tendering. However, procedural capability will be necessary for the SME contractor’s successful submission of the tender, even under a selective mode of tendering. Qualitative study with a large sample could be conducted to how SME firms could acquire and effective utilise the necessary resources for competitive advantage in public construction procurement in the Zambian Construction Industry.

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The Causes and Cost Implication of Poor Site Management on Construction Projects

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ABSTRACT

Purpose
The success of construction projects lies in the effective management of the construction sites. Poor construction management leads to cost and time overruns thereby affecting project delivery. The study aimed to investigate causes and cost implications of poor site management on construction projects, with a view of devising strategies to improve the management of construction projects.

Design/methodology/approach
A qualitative approach was employed to purposively collect data based on literature review, using semi-structured interviews from sixteen built environment professionals based in Gauteng and Free State Provinces. Collected data was analysed using content analysis protocols.

Findings
The findings indicate that causes of poor site management have a negative effect on project delivery resulting in cost and time overruns. Further, the study established systems used on sites to ensure effective management site management.

Practical implications
The identified strategies to help improve construction stakeholders to effectively manage sites in a cost and timely manner for improved success of the construction site management.

Original/value
The findings will inform construction stakeholders with strategies to effectively manage construction sites in a cost and timely manner for improved success of the construction projects.
Keywords: Causes and Cost Implication. Poor Site Management. Project Delivery.
1.0 INTRODUCTION

Site management is a highly important role, as it controls the operations and planning of site for present and future days (Jackson, 2020; Naoum, 2016). With improved site management, the flow of work is well organised and much easier to control and complete (Brian, 2018). It allows for project to be executed according to schedule, within costs and to acceptable quality (Larsen, Shen, Lindhard and Brunoe, 2016). Without new construction within towns and cities, societies could suffer from a lack of facilities and infrastructure which they may need to flourish (Harif, 2018). Construction builds a society; hence the construction industry is critically important and further places importance on good site management and efficiency to ensure a better and more comfortable society (Brian, 2018).

Management controls the way work flows, from making sure timely delivery of materials, placing utmost importance that construction is up to date and in line with schedule (Harif, 2018). These are some of site management tasks which need to be completed with diligence by the site manager. It is mentioned that management is crucial for the success of the construction project (Harif, 2018). Management is made up of leadership, the idea of leadership generates and creates the theory and practice of organizations, further the way we understand organized action and its possibilities. The concept of leadership and practice includes various forms of direction are so perfectly acknowledged that the absence of leadership is often seen as absence of organization (Smircich, 1982). Construction management addresses proper and effective planning, monitoring, application and coordination, reporting of business processes, production and finance in order to achieve economic success (Harris, 2013).

The construction industry is a highly regarded sector to the economy and plays a very important role in social and economic development (Ofori, 2015). The construction industry has specific features, which is key to be understood in order for the industry to perform efficiently and effectively (Ofori, 2015). Hence, ensuring that construction runs smoothly and efficiently to allow construction activities to be completed on time, therefore placing importance on the management of a construction site (Brian, 2018). This is the reason for the need of effective construction site management. Research suggests that the construction industry faces challenges when it relates to ensuring effective and successful communication throughout the lifecycle of the project, resulting in project failure (Gamil, 2017).

The problem of delays in the construction industry is a global phenomenon (Sambisivan, 2007). One of the biggest issues on construction sites which lead to failure is inadequate or poor management (Harif, 2018). Causes of project delays is a weak and ineffective project management, lack of responsibility and poor organization (Harif, 2018). The most addressed effects are the impact of project completion time and the additional costs which come with poor management of site. While the main effects of poor management are the risk to project and could result in a project not been financially feasible due to incurred penalties obtained because the site was not completed on time. And in extreme cases the site being totally abandoned (Abdullah, 2009). These further places importance on site management and how impactful it is on project delivery if not conducted correctly and efficiently (Harif, 2018). The importance of proper, quality and regulated management is clearly of high importance within construction. Hence the problem in poor management, its causes and effects and how it can be eliminated is of importance.

2.0 CAUSES OF POOR SITE MANAGEMENT

Several authors have highlighted causes of poor site management in literature. (Harif, 2018; Sambisivan, 2007; Ofori, 2015). For example, Sambisivan (2007) conducted a study entitled "Causes and effects of delays in Malaysian construction industry". The research identified nine causes and effects of delays on construction sites. These include contractors improper planning; contractors’ poor control of site; inadequate contractor experience; problems with sub-contractors; shortage in materials; problem with labour; equipment
availability and failure; poor communication between parties and critical mistakes during construction phase (Sambisivan, 2007). It is evident that these causes are related to poor site management. Another research conducted by Clanak (2010) revealed that some of the main causes of poor site management are labour issues, communication barriers, material shortage and poor planning. Furthermore, construction site face challenges such as delays in completion, communication and a problem explaining to the client why there are issues on site (Al-Momani, 2000). One similarity between these mentioned causes is that they all relate directly to what a site manager should be able to control. The definition of management as mentioned in the research, clearly states skills like control, leadership and communication (Al-Momani, 2000).

A study by Assaf and Al-Hejjii (2006) shows how poor site management impacts the schedule of the project and causes lengthy delays which proves to be devastating for the project. Poor site management in relation to delays refers to poor judgement on site, incapable project managers handling the project, proper and informative risk management not conducted, poor communication between the professional team and contractors (Famiyeh, Amoatey, Adiku and Agbenohevi, 2017). The stated delays are highly influential on the probability of the project meeting its desired outcomes as they impose serious implications and should be dealt with accordingly (Assaf and Al-Hejjii, 2006). Hence the importance of implementing proper and effective project management from the beginning can, in essence protect and allow the project to achieve its set out desires (Ferede, 2020; Al-Momani, 2000).

2.1 Effects of Poor Site Management in Project Delivery

One of the major issues in large construction industry is its frequent delay which decelerates the multiplier effects to the economy (Abdullah, 2009; Osei, 2013). Where poor site management is prevalent, construction delay, loss of profit on project, additional costs to project and importantly negative impact of economy are some major effects caused by poor site management (Kikwasi, 2020; Larsen et al., 2016). Effects from the result of mismanagement is not always something temporary, and in some cases, it has proven to be ongoing for months and sometimes years on projects (Ferede, 2020). In other cases, it can be detrimental to a project, in ways such that the project been abandoned, sold, dissolved or abolished (Famiyeh et al., 2017). Further, effects of poor site management in project delivery include penalties resulting in loss of profit; unexpected and additional expenses of running site for prolonged periods; negative impact on personal career of construction managers managing the sites. In extreme cases abolishment of site; negative impact to economy; and impacting the reputation of the construction (Kikwasi, 2020).

Effects vary as they could be short term and easily recovered, or long term and timeously to recover (Abdullah, 2009; Haseeb, 2011; Kumar, 2016). Short term effects which can be easily recovered such as a short extension of construction time, is something which can be dealt with quickly without the effect being detrimental (Wang, Wang, Sepasgozar and Zlatanova, 2020). Such effects could be caused by varying impacting the construction site such as poor communication, between manager and contractor, contractor and sub-contractor or sub-contractor and manager, it goes in many directions (Kikwasi, 2020). The main effects that are involved with these mentioned causes are penalties imposed on the contractor as result of delays (Sunjka and Jacob, 2013). With this the effect the impact of delays also brings about the loss in profit for both contractor in penalties and client in terms of not making use of the building due to the delays (Abdullah, 2009). Project delivery is the most important aspect regarding the client. The client expects the project to be completed within a specified time frame and within a pre-determined amount (Tipili, 2014). This is one of the major areas where poor site management causes high negative impacts on project delivery (Gamil, 2017). The effects of project delays bring about cost implications, project time expansion, penalties incurred due to the delays, destruction of one’s professional career etc (Sunjka and Jacob, 2013). Hence the importance of efficient and effective site management from the planning stages, through to the execution phases and lastly the completion phases and site handover. As quality management is required through every phase of the project (Tipili, 2014).

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Risk management plays a very important role in the process of project delivery, carefully planning for risks by the professional team can allow for insurances to be set in place as protection (Ferede, 2020). There are many risks present around the construction environment from external factors such as natural disasters to political influence and internal factors such as material shortage, price escalations etc (Osei, 2013). These risks if not effectively planned for play a serious impact on project delivery. They may entail prolonged delays, exponential cost increase, and could result in an entire project being abandoned or left incomplete in result of these risks that may have been incurred as result of initial poor site management (Famiyeh et al., 2017). Therefore, further importance is placed on proper and precise risk management and risk control throughout the project from the planning phases (Nebo, 2020). As identified, risk management is highly important in ensuring the project runs smoothly and within the specified time (Ferede, 2020). Risk management demands effective and detailed planning by the professional team from the initial planning stages which demands quality management to be placed over the control and management of risks (Kikwasi, 2020).

2.2 Systems used on Sites to ensure Effective Site Management

Construction site performance is important in ensuring workflow is conducted in a well organised manner ensuring a smoothly running of the project site (Shen, 2007). The first and foremost important checklist to run on the construction site, is on the manager who will be appointed to control the flow of works on the project, as well as the professional team who are tasked to design, develop and manage the cost of the project (Nebo, 2020). Checklists includes background checks on individuals, checks on criminal records, references from reputable sources such as previous employers, previous clients project they have worked on (Famiyeh et al., 2017). Such procedures can be taken to aid the selection of the professional team and managing the construction site. Focussing on other causes of poor site management, such as security issues, other checks such as equipment checklists; pre-work checklists; quality and certification checklists; detailed safety checklists and general safety checks can be undertaken (Kikwasi, 2020).

Checklists are a great tool to use to optimize how to organize the construction project in a number of ways (Nebo, 2020). These checklists are devised as an effective approach to managing project sites which requires detailed organization. In each specific checklist, planning well ahead in construction, ensuring the required labour and skill for the project, time required to complete tasks, security details and storage for project are some important checks that need to be attended to in a timely manner (Kikwasi, 2020). Checklists develop a procedure which can be followed and utilised by many projects. It creates a certain level of security as well as organisation and detailed understanding (Landoll, 2021). Making effective use of developed checklists for each and every aspect of the project, in essence allows for site management improvement (Harris, McCaffer, Baldwin and Edum-Fotwe, 2021; Nebo, 2020).

2.3 Strategies that can help Improve Site Management Efficiency

There are strategies that can help improve site management in order to improve construction productivity. According to Fazli, Fathi, Enferadi, Fazli and Fathi (2014), utilizing construction management software improves such as Building Information Modelling [BIM] improves construction project planning and monitoring. Further, the improved planning process helps enhance the operational efficiency through employee productivity, safety and risk mitigation (Radosavljevic and Bennett, 2012).

Efficiency brings about savings to the client, less wastage, better ratings to the construction site in terms of been green and overall improved organization of the construction site (Anna Sobotka, 2016). Efficiency on site can be highly effective if implemented in the correct aspects such as dispatch of materials, improved security, skilful labour, making use of rented equipment in multiple parts of the project at once and effective planning ahead (Wang, 2019). Efficiency as a strategy at a construction site, entails employing ways to improve the overall flow of works, cashflow required, appointment of duties and clarity on instructions (Anna Sobotka, 2016). Areas
on which efficiency can be improved include: control in efficient and cost effectiveness in the procurement of materials; improved security measures to reduce theft; making use of skilful labour to reduce wastage; clear and direct instruction on what is to be done, adhering to accurate plan of works (Wang et al., 2020).

Implementing efficiency is a challenging task, with this will come obstacles. Obstacles including complexity of the project, required labour skills, design and engineering processes, use of speciality equipment and knowledge (Wognum, Bill, Elgh, Peruzzini, Stjpandic and Verhagen, 2019). And other factors are all challenging obstacles to be faced in looking to implement efficiency on the construction project (Council, 2009). Obstacles can be controlled by ensuring effective planning on the project and what will be the most efficient way to approach the obstacle, whether it be finding alternatives, re-designing that section or acquiring specialty services or skill sets to conduct that section of work (Council, 2009; Sobotka, 2016). There are ripple effects created by quality management and the benefits that quality management brings to the project, thereby creating a certain level of desired construction project quality (Anna Sobotka, 2016).

Improvement to site management requires a competent site manager to oversee the project including implementing improved security, clear and direct instructions (Harris, McCaffer, Baldwin and Edum-Fotwe, 2021). Furthermore, the site manager should be able to handle material requirement for construction progress, including ensuring that there are sufficient materials to avoid project delivery delays (Wang, 2019). Another strategy to use in system management, is involve key professional project stakeholders in weekly/monthly meetings on what has been completed and projected milestones including project finances (Vacanas and Danezis, 2021). And from this meeting provide direct instructions to those who require it, such as the contractor as to what is to be conducted next (Wang, 2019).

3.0 METHODOLOGY
The study utilised a qualitative research method which provided an understanding and insight in the research problem understudy. The chosen approach enabled the researchers to focus on obtaining data through open-ended and conversational communication (Creswell, 2014). Semi-structured interviews were administered to sixteen [16] purposively selected registered Quantity surveyors, Architects, Construction and Project managers. This enabled the researchers to target and solicit information from specific professionals with sufficient knowledge about the research topic understudy (Bryman, 2016).

Content and thematic analysis was used to analyse and interpret the collected data. This enabled the researchers to extract the information supplied by the study participants (Lune and Berg, 2017). The data was prepared following qualitative protocol suggested by Creswell (2014). The unit of analysis was classified. Categories were generated and the text was coded. The coded data sets were then checked for consistency. Inferences and conclusions were derived from the data (Miles and Huberman, 1994).

4.0 RESULTS
4.1 Demographic information of participants
Illustrations must be clear and unfolded, and their print quality must be even and dark enough for reproduction. If you are creating line drawings by hand, they should be drawn in ink on tracing paper or white paper.

Table 4.1 Demographic information of participants.

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profession</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Manager</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Construction Manager</td>
<td>3</td>
<td>19</td>
</tr>
</tbody>
</table>
Yusuf Hadia, Kahilu Kajimo-Shakantu and Charles Poleni Mukumba

<table>
<thead>
<tr>
<th>Role</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architect</td>
<td>2</td>
<td>12%</td>
</tr>
<tr>
<td>Quantity Surveyor</td>
<td>6</td>
<td>38%</td>
</tr>
<tr>
<td>Civil engineer</td>
<td>1</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geographical Location</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauteng</td>
<td>10</td>
<td>62%</td>
</tr>
<tr>
<td>Free State</td>
<td>6</td>
<td>38%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work Experience</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 years</td>
<td>6</td>
<td>38%</td>
</tr>
<tr>
<td>6-10 years</td>
<td>5</td>
<td>31%</td>
</tr>
<tr>
<td>11-15 years</td>
<td>3</td>
<td>19%</td>
</tr>
<tr>
<td>16 years and above</td>
<td>2</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td>100%</td>
</tr>
</tbody>
</table>

The analysis of the participants information is presented in Table 4.1. As shown in Table 4.1, 38% of the participants are Quantity Surveyors. This is followed by participants who are Project Managers 25%, Construction Managers 19%. Participants who are Architects and a Civil engineer are represented by 12% and 6% respectively. Most participant are based in Gauteng province as represented by 62%. The remaining 38% are based in Free State province. The analysis of the participants data shows that majority of the participants [38%] have 1-5 years experience, followed by 6-10 years’ experience at 31%. Participants with 11-15 years’ experience and those with 16 years and above experience are represented by 19% and 12% respectively.

4.2 Causes of Poor Site Management
Participants were asked what they would consider to be the causes of poor site management. Most respondents [42%] said “…changes in project plan and details causes poor site management…”. About 28 percent of the respondents indicated poor communication on site as one of the causes of poor site management “…poor communication causes a lot of delays which results in poor site management…” Inaccurately compiled Bill of Quantities and lack of knowledge and experience “…lack of experience in managing a construction project result in poor site management…” were also cited as causes of poor site management by 30 percent and 10 percent of the respondents respectively.

4.3 Effects of Poor Site Management in Project Delivery
Effects of poor site management emerged as the second theme identified in the analysis of data. The respondents were asked what they considered to be the effects of poor site management on project delivery. Most of respondents indicated cost and time management as the effects of poor site management in Project delivery. The participants [52%] said “…there will be an upward change in the project budget, requiring more materials to be procurement…” Additionally about 48 percent of the participants said “…there will be a loss of time resulting in failure to meet the project deadlines…”

4.4 Systems used on Sites to ensure Effective Site Management
Systems used on sites to ensure effective site management was another theme that emerged from the
data analysis. Most respondents [65%] indicated that project scheduling with deadline and deliverables; clear lines of communication as the systems most used on sites to ensure effective site management, they said “...project schedule with deadlines and deliverables in place helps to ensure effective site management...” others said that “…when clear lines of communications are in place, management of sites is effective...”. About 35 percent of participants indicated background checks on professional team and labour skillset as a requirement to be in place to ensure effective site management “…there should be a background check on the competence of the professional team members and the skillset of the labourers..., if sites are to be managed effectively…”

4.5 Strategies that can help Improve Site Management Efficiency

The respondents were asked “...what strategies can be devised to improve site management efficiency...”. Most of the respondents [85%] indicated that communication, strict adherence to deadlines and deliverables, qualified personnel on site as the strategies required to improve site management efficiently. Furthermore, other respondents said that engagement of effective occupational health and safety policy, engagement of site security systems, timely procurement of materials in required quantities as an effective strategy to improve site management efficiency.

5.0 DISCUSSION OF RESULTS

The results revealed that changes in project plan and details causes poor site management, poor communication on site, inaccurately compiled Bill of Quantities, lack of knowledge and experience as the causes of poor site management. The results correspond to the findings by Sambisiavan (2007) whose study identified nine causes of poor site management. The results indicate that poor communication among site stakeholders largely contributes to poor site management. The identified causes of poor site management impact the project schedule and delivery period for the project International Journal of Project Management, 2006). As such the identified causes of poor site management should be mitigated to reduce the risks of project failure (Ferede 2020).

The study findings have shown that budget overruns and poor time management as the effects of poor site management in project delivery, thereby affecting project deadlines. The results agree with those reported in literature by previous authors that loss of profit, additional project costs are some of the major effects of poor site management (Abdullah, 2009; Haseeb, 2011; Kikwasi, 2020). The identified effects of poor site management are detrimental to the project which can lead to the project been abandoned (Kikwasi, 2020). Haseeb (2011), suggests to undertake remedial measures to minimise effects of poor site management in a timely manner to avoid overspills such as loss of profit, penalties and other additional expenses for running the construction site.

The study established that project scheduling with deadline and deliverables; clear lines of communication are the most used systems on sites to ensure effective site management. Further, the results have shown that a background check on professional team and labour skillset is an important measure to be in place to ensure effective site management. The results agree with those reported by Nebo (2020) that there should be a clear line of communications among construction site stakeholders to ensure effective site management. Further, Nebo (2020) suggests to do a background check on the individuals to be appointed as to manage the construction site to ensure their suitability to effectively manage the construction site. Construction sites to be managed effectively require a deliberate system put in place. As such the results suggest that there should be mechanism in place for the managing the sites effectively.

The research findings revealed that communication, strict adherence to deadlines and deliverables, and qualified personnel on site are some of the strategies that could help improve site management efficiently. Furthermore, the results have shown that engagement of effective occupational health and safety policy,
engagement of site security systems, timely procurement of materials in required quantities are effective strategies that improve site management. According to Wang (2019), strategies to improve site management should be implemented correctly. Effectively employing strategies helps to improve the construction works productivity, clear communications and execution of works in a timely manner according to schedule (Sobotka, 2016).

6.0 CONCLUSION AND RECOMMENDATIONS

The paper examined that causes and cost implication of poor site management on construction projects. The findings of the study provide insight in effective site management by establishing causes of poor site management. This will enable construction project stakeholders to put in place strategies that will ensure effective management of construction sites. Further, the study investigated the effects of poor site management in project delivery and established the systems currently utilised on sites to ensure effective site management. Poor site management has effect on timely delivery of projects within budget. The study recommends employing strategies such as having systems in place planning and monitoring construction works. This will ensure effective site management for delivery of construction projects. And minimise cost overruns, project delay and quality of construction project to stakeholders’s satisfaction.

7.0 REFERENCES


Dispute-prone clauses in standard conditions of building contracts for construction projects in Tanzania: a qualitative study

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ABSTRACT
Purpose: This study aims to identify contract clauses which are prone to disputes from National Construction Council (NCC) Agreement and Schedule of Building Conditions of Building Contract (With Quantities), and, Public Procurement Regulatory Authority (PPRA) General Conditions of Contract (GCC) by reviewing arbitration cases in order to minimize disputes hence improve project delivery.

Design/methodology/approach: The qualitative approach adopted in this study involved arbitration cases conducted under National Construction Council and arbitrators. Judgmental sampling technique was used to obtain a representative sample of 25 building construction projects cases and five arbitrators. Nine and 16 arbitration cases for NCC Agreement and Schedule of Building Conditions of Building Contract (With Quantities) and PPRA GCC respectively were reviewed. Data was collected through documentary review and interviews and thematic analysis-Nvivo was used to analyze the data.

Findings: Among the 42 clauses of NCC Agreement and Schedule of Building Conditions of Building Contract (With Quantities) 10 were prone to disputes and out of 72 clauses PPRA GCC 14 were found prone to disputes.

Research implications: The findings provide insights on dispute-prone clauses arising from the use of standard forms of conditions of contract in order to improve project delivery. They are useful to construction project stakeholders in minimizing disputes during project planning by properly allocating risks and obligations in the clauses prior to entering into a contract. Future research may be undertaken to analyze how and the extent to which identified clauses lead to disputes.

Original/value of paper: The study has identified areas that are prone to disputes, linked them to contract clauses and explored circumstances for dispute-prone contract clauses from NCC and PPRA standard forms of contract for building construction projects in an un-explored, Tanzanian context.

Keywords: Building construction projects, disputes, dispute-prone clauses, standard conditions of contracts
1. INTRODUCTION
Disputes in construction projects are considered as an impediment on successful project completion as they affect project progress and strains relationship among parties to a contract. One of the areas to carefully consider in the event of dispute is the form of conditions of contract in use. The crafting (framing) of standard forms of conditions of contract ought to consider all technical and socio-economic contexts. With advancement in technology and mammoth requirement of infrastructure in developing countries Tanzania included, there has been increase in size and complexities in the nature of projects (Iyer et al., 2008). This complexity gives rise to further ambiguities in the prevailing contract forms eventually making the forms more complex and difficult to interpret, suggesting increased possibility of disputes occurrence. Previous studies (Burton, 1990; Cheung et al, 2002; Chan et al, 2005; Jaffer, 2011 and Madhumitha, et al 2020) have explored on conflict prevention, dispute resolution (such as Alternate Dispute Resolution (ADR) mechanisms), avoidance & minimization, and arbitration for different forms of contracts (CFCs) in various countries in the building and civil engineering sector. This is because, the use of rigid agreements may not be appropriate for most construction projects that operate under conditions of uncertainty and may be a source of disputes.

The standard forms of contract are developed with the guidance from industry regulations, code, organization and gives common ground for contractual clarifications and definitions Jaffar et al (2011). The authors argue that the perfect set of standard conditions of contract does not exist. This is to allow for specific contract provision suitable for a specific project. The broadness of the provisional standards of contract however, is to ensure that the contract addresses and encompasses as much terms and situations as possible. While researchers have reviewed different conditions of contract and analyzed how the contract clauses can lead into disputes associating with project size, context, nature, complexity, administration and procurement method (Jagannathan & Delhi, 2019; Divakar & Kumar ,2015; Perelini & Singh, 2013; Menches & Dorn, 2013), little is known on how and which contract clauses attract disputes relative to the nature of clients involved (i.e. private against government projects). For example, Divakar & Kumar (2015) from India investigated the International Federation of Consulting Engineers (FIDIC) for clauses which lead into dispute, as well as Menches & Dorn (2013) in Chicago who analyzed the language used in a contract clause from different standards forms of contract that is American Institute of Architects (AIA), Chicago Public Building Commission (PCB), Consensus Docs 300, and Integrated Form of Agreement (IFOA).

Thus, the aim of this study is to identify dispute prone-clauses in the standard conditions of contract (NCC vs. PPRA forms) for building construction projects in Tanzania. The NCC form whose first edition was published in 1995 was later amended in 1998 to include, issues of environmental protection and care for the works, indemnity, insurance and dispute settlement clauses. In 2000, the agreement and schedule of conditions was then amended to introduce a clause which will deals with corruption in construction projects. This form was used for both private and government projects before enactment of the Public Procurement Act (PPA) in 2011 where the PPRA forms of contract came in full force for all government projects, and the NCC form remained in use for private projects to date. The PPRA form of contact has undergone several reviews with the last review dated in 2022. The fact that projects are unique in terms of size, context, nature, complexity, administration, procurement method and parties involved, the use of standard conditions differ from one project to another. It is therefore important to determine dispute-prone clauses by focusing on the most used standard conditions of contract (NCC and PPRA) for building construction projects in Tanzania.

2. LITERATURE REVIEW
Condition of contracts: the overview and context
The construction conditions of contract are used to guide the interaction of parties, provide security and promote positive interactions and project outcomes (Menches & Dorn, 2013; Wang et al, 2019). However, the said conditions of contract can be a source of disputes as noted in the study by Menches & Dorn (2013) after analysis of a single clause from forms of contact and noting that, although the message from the clause was the same, it triggered different reactions. In addition, disputes arise because of contract clauses that can be interpreted in more than one way (Patil et al., 2019; Perelini & Singh, 2013; Jaffar et al., 2011). In other words, the contract document itself can become a source of disputes (Chong et al, 2012). Previous research has shown that if disputes are not resolved promptly, they tend to drag on and escalate and can cause project delays, lead to claims, require litigation proceedings for resolution, and ultimately destroy business relationships between the parties apart from the time and cost overruns (Cheung, Henry & Lam, 2002 in Acharya, Lee, & Kim, 2006; Iyer et al., 2008; Chaphalkar et al., 2015; Maemura et al, 2018).

**Disputes versus conflicts**

There have been confusions between disputes and conflicts. It is therefore necessary to briefly highlight the difference between the often-interchangeable terms. According to Burton (1990), a dispute is a short-term disagreement that can result in the disputants reaching some sort of resolution; it involves issues that are negotiable. Conflict, in contrast, is long-term with deeply rooted issues that are seen as “non-negotiable” (Burton, 1990). The discussions in this study are based on construction disputes by specifically mapping dispute-prone clauses in Tanzania’s construction contracts context. The question of whether or not conflicts (as opposed to disputes) in construction projects take relatively long to deal with compared to other sectors, attract further study to categorically inform construction experts.

**Sources and causes of disputes.**

Many contractual problems stem from the project process itself (Aryal & Dahal, 2018) and are linked from both pre-contract to post-contract phases of the project. These processes include inter alia; procurement, tenders & bidding, design, letters of intent, Programme, extensions of time, delays analyses, liquidated/delayed damages, variations, loss & expenses, payments, practical completion & defects, rights & remedies and adjudication (Knowles, 2012). Cakmak & Cakmak (2014), Madhumitha et al (2020) and Shash & Habash (2021) carried out a comprehensive literature review to map all possible causes of construction disputes and classified them into main categories. For example, Cakmak & Cakmak (2014) analyzed the antecedents using the analytical network process (ANP) approach to determine their relative importance. The results showed that main disputes categories were owner related disputes, contractor related disputes, design related disputes, contract related disputes, human behavior related disputes, project related disputes and external factors. Furthermore, the analysis revealed that the contractor related disputes and their sub-dispute categories are the most common ones in the construction industry. Contract related dispute factors rank second, citing sub-dispute causes as ambiguities in contract documents, different interpretations of the contract provisions, risk allocation and other contractual problems.

The work of Acharya et al. (2006) has identified critical construction conflicting factors using Analytical Hierarchy Process (AHP). A similar study by Acharya, Lee & Im (2006) was done in Korean and both studies revealed owner and consultant are mostly responsible parties for conflicts in construction projects. Comparing the works of Acharya et al. (2006) and Cakmak & Cakmak (2014), we note that Cakmak & Cakmak (2014) have systematically mapped causes of disputes in a categorical manner. We therefore advance the work of Cakmak & Cakmak (2014) by specifically dissecting the contractual related category and looking into dispute-prone clauses related to ambiguities in contract documents, different interpretations of the contract provisions, risk allocation and other contractual problems using the PPRA and NCC contract forms.
Dispute-prone clauses

Malekela (2018) conducted interviews with consultants on the use of NCC standard conditions of contracts, and identified some NCC clauses which have unclear information and can lead into disputes. Often these risks/uncertainties arise from ambiguity in drafting and interpretation of different clauses in the construction contracts (Iyer & Satyanarayana, 2002; Jagannathan & Delhi, 2019; Patil et al., 2019). One of efforts to minimize resulting disputes is to ensure standard forms are updated periodically with necessary revisions to suit the changing construction landscape (Jagannathan & Delhi, 2019). International Federation of Consulting Engineers (FIDIC) and the World Bank for example conduct reviews on their SFCs and guidelines at least after every two years. In so doing, any observed ambiguity in the course of administering construction projects are noted, and misinterpretations are rectified accordingly.

Although Divakar & Kumar (2015) agree that the conditions of contracts should be reviewed from time to time and more details should be added to contract clauses which are prone to disputes, the researchers after conducting an extensive review of fifty (50) cases of disputes from projects using the FIDIC conditions and identifying, effects of not properly addressing the issue of changes of time and cost, suspension of work, defective work, contractor and employer’s risks as sources of disputes, they warn against upsetting the balance of the general conditions by commonly amending certain clauses.

3. METHODOLOGY

The qualitative research approach was employed. The approach was quite useful due to its ability to provide textual description on how certain individuals, experience the dispute-prone contract clauses in building projects in Tanzania (Bhojanna 2012). The study had two types of population; the first population included all cases of disputes submitted for arbitration to the NCC. These cases were used to identify contact clauses in the NCC and PPRA standard conditions of contract forms which are prone to disputes. Moreover, from arbitration cases, it was not only possible to identify contract clauses which are prone to disputes but also understand the circumstances (poorly written contracts with double meaning, language complexity of contract clauses, different interpretation of contract provisions) that leads into such disputes (Cakmak & Cakmak 2014; Divakar & Kumar 2015; Ejohwomu et al, 2016; Grant et al, 2014; Jaffar et al, 2011; Malekela 2018; Menches & Dorn 2013; Perelini & Singh 2013; Poerdiyatmono 2007 as cited by Rauzana 2016). The second intended population involved arbitrators, to further discuss the contract clauses which are prone to disputes. Arbitration cases were selected because the dispute is litigated or resolved by means of a dispute resolution mechanism like arbitration, mediation, adjudication or going through the Dispute Review Boards (Arditi and Patel 1989 in Patil et al., 2019; Love et al, 2010). Among these processes, arbitration is a formal and quasi-judicial process (Jagannathan & Delhi, 2019).

Judgmental or deliberate sampling was used, in selecting both cases and arbitrators that were most likely to give information on the conditions of contract as a source of disputes. Deliberate sampling technique allowed the selection of a sample of individual items that are most likely to represent the targeted population and provided information on dispute-prone contract clauses for building projects. The only building construction cases from 2000 to 2021 that used NCC or PPRA forms of contract were selected, which amounted to twenty-five cases only, the selected time frame was important because the last amendment of the NCC forms of contract was done in 2000. The selected projects, includes private and public clients, and they range from new construction to rehabilitation projects. Twenty-five (25) arbitration cases formed the sample frame and were all included in the sample size. Moreover, five arbitrators were selected because they have more experience in settling disputes as opposed to other stakeholders. Additionally, a judge, an advocate, an Architect, an Engineer
and a Quantity surveyor were selected as key informants who brought in diversification of processional competences as indicated in Table 1, hence obtaining data from different perspective and for triangulation reasons (Yin, 2014).

Table 1 Demographic information of arbitrators selected for interviews

<table>
<thead>
<tr>
<th>Variable</th>
<th>Categories/attributes</th>
<th>Number</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
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<td>100%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Education</td>
<td>PhD</td>
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<td>20%</td>
</tr>
<tr>
<td></td>
<td>Masters</td>
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<td>80%</td>
</tr>
<tr>
<td></td>
<td>Bachelors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profession</td>
<td>Diploma</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Architect</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Engineer</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Quantity Surveyor</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Advocate</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Judge</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td>Professional experience (years)</td>
<td>&lt;5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-10</td>
<td>2</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>10-15</td>
<td>3</td>
<td>60%</td>
</tr>
<tr>
<td>Arbitration experience (years)</td>
<td>&lt;5</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>5-10</td>
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<td>40%</td>
</tr>
<tr>
<td></td>
<td>10-15</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>&gt;15</td>
<td>2</td>
<td>40%</td>
</tr>
<tr>
<td>Arbitration cases attended</td>
<td>0-5 cases</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-10 cases</td>
<td>2</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>10-15 cases</td>
<td>1</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>15-20 cases</td>
<td>2</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>20 and above</td>
<td>2</td>
<td>40%</td>
</tr>
</tbody>
</table>

Data were collected through documentary review and semi-structured interviews. As indicated in Table 1, data collection through documentary review was from the available NCC documents used in identification of contract clauses from NCC and PPRA which are prone to disputes. All the arbitration cases and clauses which seemed to have caused disputes were jotted down. Also, semi-structured interview was used to get arbitrators opinions on the subject matter. The interview questions included what are the main areas in forms of contract that are prone to disputes? What causes disputes in the identified areas? How to solve the disputes? Probing was done in order to get more information about the research questions, for example, which contract clauses are prone to disputes? How do those clauses cause disputes? Each interview lasted between 15 minutes and 30 minutes. Interviews proceeded until the saturation point was reached and there were no new information/opinion from the participants.

The study used NVivo for analyzing data from interviews and documents. This software was used due to the fact that, it could rigorously analyze unstructured text, audio interviews, and focus group discussion among
Sylvia Joseph Mtendamema, Nyamagere Gladys Sospeter, Didas Simon Lello and Geraldine John Kikwasi

others (Godau, 2004). The themes emerged from the analysis. The thematic analysis using NVivo through text search and word frequency, identified themes from the documents obtained from NCC and PPRA were presented. Themes and sub-themes which are significant in explaining the research issue were identified and presented.

4. DATA ANALYSIS

The twenty-five (25) building cases which fit into the pre-set criteria were reviewed in which, sixteen (16) cases fell under PPRA form of contract and nine (9) under NCC form, which is 64% and 36% respectively. This implies that contract clauses in PPRA forms of contracts are more susceptible to disputes compared to NCC. The thematic analysis using NVivo through text search and word frequency, identified themes from the documents obtained from NCC, by categorizing frequent words that were meaningful to the study as indicated in Figure 1.

![Figure 1. The word cloud, showing themes from documentary review](image)

After identification of themes, data was coded to form Figure 2 which indicates the frequency level of disputes in each of them. From the identified themes and sub-themes, the researcher linked the themes with contract clauses from NCC and PPRA forms of contract, as indicated in Table 2, thus identifying contract clauses which
are prone to disputes.

Figure 2. The themes and sub-themes obtained after coding the data into the nodes
From the review of sixteen (16) cases of projects which used PPRA forms of contract, clause 67 and 68 which are termination of contract and payments upon termination occurred the most in eight (8) cases out of the sixteen (16) reviewed equating to 50%. This was followed by clause 57 which is liquidated damages that occurred in four (4) cases out of the total reviewed which is equating to 25%. While clause 56 retention, clause 47 and 48 variations and payments of variations, clause 34 program and clause 2 interpretation had the least occurrence in the cases, as they appeared in a single case each which is equal to 6%.

From the review of nine (9) cases of projects which used NCC forms of contract, clause 28 determination by employer occurred in four (4) cases out of the nine (9) reviewed. This was followed by clause 34 which is certificates and payments that occurred in three (3) cases out of the total reviewed. While clause 19 assignment, clause 29 determination by contractor, clause 26 variation of time for completion, clause 36 advance payment and clause 42 corruption had the least occurrence in the cases, as they appeared in a single case each.

5. DISCUSSION
5.1 Exploration of dispute-prone contract clauses
Through documentary review, several themes were identified as shown in Table 2 and Figure 2. The findings show that payments, termination, variation and work progress have occurred in several projects. The identified themes were linked with contract clause from NCC and PPRA forms of contract, which resulted into identification of contract clauses that are prone to disputes.

Table 2 Themes and sub-themes linked with specific clauses from PPRA and NCC forms of contract

<table>
<thead>
<tr>
<th>THEMES</th>
<th>SUB-THEMES</th>
<th>CLAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payments</td>
<td>Advance payment</td>
<td>Clause 36-NCC, Clause 59-PPRA</td>
</tr>
<tr>
<td></td>
<td>Loss and expense</td>
<td>Clause 27-NCC, Clause 53-PPRA</td>
</tr>
<tr>
<td></td>
<td>Certificate and payments</td>
<td>Clause 34-NCC, Clause 51-PPRA</td>
</tr>
<tr>
<td></td>
<td>Performance security</td>
<td>Clause 60-PPRA</td>
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<td></td>
<td>Liquidated damages</td>
<td>Clause 57-PPRA, Clause 25-NCC</td>
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<tr>
<td></td>
<td>Retention</td>
<td>Clause 56-PPRA</td>
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<tr>
<td></td>
<td>Payments of variation</td>
<td>Clause 48-PPRA</td>
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<td></td>
<td>Payments upon termination</td>
<td>Clause 68-PPRA</td>
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<tr>
<td>Termination</td>
<td>Termination of contract</td>
<td>Clause 67-PPRA</td>
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<tr>
<td></td>
<td>Determination by employer</td>
<td>Clause 28-NCC</td>
</tr>
<tr>
<td>Variations</td>
<td>Variation</td>
<td>Clause 29-NCC</td>
</tr>
<tr>
<td></td>
<td>Variation of time</td>
<td>Clause 26-NCC, Clause 35-PPRA</td>
</tr>
<tr>
<td>Work progress</td>
<td>Possession of site</td>
<td>Clause 27-PPRA</td>
</tr>
<tr>
<td></td>
<td>Program of work</td>
<td>Clause 34-PPRA</td>
</tr>
<tr>
<td>Interpretation</td>
<td>..........</td>
<td>Clause 2-PPRA</td>
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<tr>
<td>Assignment</td>
<td>..........</td>
<td>Clause 19-NCC</td>
</tr>
<tr>
<td>Corruption</td>
<td>..........</td>
<td>Clause 42-NCC</td>
</tr>
</tbody>
</table>

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a) Payment
Payment is one of the themes that emerged from this study, with 8 sub-themes including payment, loss and expense, certificates and payments, liquidate damages, advance payment, retention payment, performance security and payment for variations. The sub-themes identified were linked to contract clauses from NCC and PPRA forms, which lead into identification of twelve clauses, four from NCC and eight from PPRA. As noted clause 57 (liquidated damages) from PPRA and clause 34 (certificates and payments) from NCC have appeared in four and three cases respectively, ranked highest as prone to dispute which will be discussed herewith apart from other payment related clauses.

b) Liquidated damages
Clause 57 liquidated damages from PPRA has appeared in four cases. Liquidated damages are the damages payable to the client following the breach by contractor after failure to deliver the works in agreed timelines. This clause is prone to disputes because parties usually claim liquidated damages without fully understanding the circumstances that would warrant for damages to apply (Malekela, 2018). In a case between a contractor vs District council a public client, for construction of a dining hall, whereby the client claimed for liquidated damages, however the arbitrator ruled that the damages cannot apply in this case because the contract signed between the parties did not indicate the duration of the contract, hence the end of contract or delays could not be determined thus damages for delays could not be applied. The contractor was paid for the deducted damages and the client paid for arbitration fees. The findings are emergent adding into the broad set of knowledge regarding contract disputes.

c) Certificates and payments
Clause 34 (certificates and payments) from NCC has appeared in three cases. The clause deals with the client making payment to the contractor for works done. A case between a Contractors against an Oil marketer company a private client for construction of a boundary wall, whereby the contractor claimed interest rate for delayed payments which was granted by the arbitrator because the client without the Architect delayed contractor’s payments by failure to determine the correct time for conducting interim valuations. The main issue in clause 34 is that, the Architect is given the power to determine the right time to conduct interim valuation at the same time the clause specify that the payments should be made in four-week interval which is not practical and usually leads into payment delays and disputes. Study suggested this clause to be re-structured to stage wise payment arrangement to avoid disputes. The findings are supported by the study of Malekela (2018)

e) Termination of contract
Termination of contract in clause 67 in PPRA form is ranked highest as a clause which is prone to disputes after appearing in eight cases. Termination of contract clause is prone to disputes due to failure of parties to determine the actual breach of contract from the contract clauses. For example, a case, between a contractor vs a bank as a public client using PPRA forms of contract in construction of the bank’s offices, a project manager terminated the contract with reason of contractor stopping the work. However, the arbitrator considered the termination unlawful because the delays were due to failure of the client to issue instructions to the contractor, and the said instruction delayed the work. The contractor received all cost payable for works done, interest rate for delayed payments as compensation and arbitration fees were paid by the client. From clause 67 in PPRA forms of contract, the project manager on behalf of the client can terminate the contract if the contractor stops works for 28 days consecutively. However, the clause is silent with regards to issues that can cause the contractor to stop the works. This silence may lead to different interpretations by either party hence cause disputes, as it can be noted that, prior to termination other issues are to be considered as well, which means that the forms of contract are tailored as one to be used as a whole. The finding is consistent with the existing research as stated by

ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa
Clamp, Cox & Lupton (2007) that one clause in conditions of contracts usually has effects on other clauses as well.

1) Determination by employer

Determination by employer has appeared in four cases ranking it the highest prone to dispute clause from NCC. Determination by employer happens when the contractor breaches the contract by not performing their obligations and employer terminates the contract. This clause is prone to disputes mainly because of misinterpretation of the clause and failure of the employer to establish the breach of contract. From documentary review, in a case between a contractor vs a church as a Private client using NCC forms of contract in construction of a workshop hall, were the client terminated the contract but the arbitrator termed the termination as unlawful because the Architect on behalf of the client only issued a single notice to the contractor and thereafter terminated the contract. The arbitrator stated that after issuing the first notice of intention to terminate, another notice should be given to signify that the contractor has not complied with the first notice. However, in clause 28 in the NCC forms of contract, it is stated the Architect can terminate the contract if the contractor continues breaching the contract 14 days after the first notice. The forms of contract are silent in regards to the second notice, and this language gap can lead into different interpretation from both parties and results into disputes, in this case the contractor was compensated for the damages and client paid for arbitration fees. The findings from this case are emergent adding into the broad knowledge of disputes issues resulting from the use of conditions of contract.

g) Variations

Variation is another theme that emerged from this study, with two sub-theme including work variations and time variations. The sub-themes identified were linked to contract clauses from NCC and PPRA which lead into identification of four clauses, two from NCC and two from PPRA as noted in Table 2. Clause 47 variations, clause 35 extension of intended completion date from PPRA appeared in a single and two cases as shown in Figure 3. Clause 13 variation from NCC which appeared in two cases and clause 26 variation of time from NCC which appeared in a single case. From the research it is noted that work variation goes hand in hand with variation in time and dispute arise due to failure of parties especially the employer/consultant to understand that variation in instructions has a direct effect on the project timelines especially in case of additions and alterations.

The above findings also supported by interview respondents as stated by the Architect “Condition of contract cannot fit specific projects. The conditions of contract are general in assisting the parties. However, some conditions of contract are most likely to cause disputes, especially issues of time and delays, payments, variations and termination of contracts. These clauses should be reviewed to see where the issue is.” Moreover, the Judge stated “The Standard form contracts are very useful. They are time-tested and their use helps to save a lot of time and unnecessary errors in the drafting of contracts. Disputes would usually arise from Sub-standard work, as caused by contractors’ technical incapacity. Although it is evident that some areas are usually the sources of conflicts like payments and time, which are delays and variation of time and works.” And the statement agrees with the study of Clamp, Cox & Lupton (2007) which states that the forms of contract are convenient to use and less expensive comparing to drafting new ones per each project, the forms are detailed and provide relevant guidance to the parties and are usually tested in court, however the study warns that amending the forms of contract to suit the project at hand, usually unbalances and distort the actual meaning of the contract clauses which leads into disputes and this is usually because the contract clauses affects one another hence when amending one clause the effects can be seen in another.

5.2 Exploration of circumstances for dispute-prone contract clauses
According to the literature, different interpretation of contract provisions, poorly written/ambiguous contracts and complex language used in contract clauses are the most common causes of contractual disputes. Three (3) out of five (5) interviewees agreed as stated by a Quantity Surveyor “The language used in conditions of contracts can allow for multiple interpretations and misinterpretation may occur because parties to a contract are trying to avoid certain risks, hence interpret clauses to their own advantage”. Also, one Architect stated that “Conditions of contract cannot fit specific projects. The conditions of contract are general in assisting the parties, but the language used in some contract clauses is complex and can easily lead into misinterpretation in certain situations.”

And one Judge added “The Standard form contracts are very useful. They are time-tested and their use helps save a lot of time and unnecessary errors in the drafting of contracts. However, contract language is left inclusive to encompasses general situations in projects, and the language used can lead into misinterpretations and disputes”

6. CONCLUSIONS

Although disputes are common in construction projects, they affect project progress and strains relationship among parties to the contract. However, there is inadequate knowledge amongst the contractual parties on areas / clauses which are prone to disputes, particularly in Sub-Saharan Africa. To address this knowledge gap, this study sought to explore dispute-prone contract clauses from National Construction Council (NCC) and Public Procurement Regulatory Authority (PPRA) standard forms of contract. The research findings have identified areas in contract conditions and linked them with clauses that are prone to disputes. It can be concluded that, payments, termination of contract, variations, work progress, interpretation, assignment and corruption are contract dispute-prone clauses from NCC and PPRA forms. These clauses are caused by language complexity and ambiguity and give a picture of something to be done in project planning and administration in order to minimize disputes. Henceforth, a need for guideline review or structured procedure to handle disputes in the construction industry. A common understanding should be placed prior to the process while involving all key project participants at the early stages of the project and to have a policy which controls and monitors successfully and efficiently all project management/administration activities in construction projects.

Theoretical implication and further study avenues

The literature review reveals that no attempt has been made to explore dispute-prone contract clauses which are prone to disputes from NCC and PPRA standard forms of contract particularly in Sub-Saharan Africa, an un-explored context. Therefore, this study has two theoretical contributions. First, this study makes a significant research contribution by identifying areas that are prone to dispute and linking them to contract clauses and how they are prone to disputes from NCC and PPRA standard forms of contract for building construction projects in Tanzanian context. Further, as opined by Summers (2001), a study can make significant contributions and add new knowledge by filling in knowledge gaps. Therefore, this research also sheds light and provides insights on the understanding of these clauses/areas that may affect project progress during post-contract (administration stage), an area previously under-researched. Second, the findings from empirical study on dispute prone clauses’ insights from the arbitrators (arbitration cases) are useful and part of project management approach to resolve disputes for the successful delivery of building projects in developing countries. This study was only focused in identifying contract clauses which are prone to dispute by considering NCC and PPRA standard forms of contract. Further studies should be undertaken to analyze the underlying source of disputes from the identified areas.
contract clauses and the extent they contribute to disputes. The extent to which contract provisions under such arrangements propagate practical problems is yet to be revealed.

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Building a Stronger Construction Industry: The Indispensable Contributions of Professional Associations and Institutes: An Australian Perspective

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ABSTRACT
Purpose of the paper
This study presents an examination of the relevance of professional associations and institutes within the construction management and economics domain in Australia. Furthermore, the study explored the role of industry players in promoting professional institute memberships, while also acknowledging the financial considerations associated with such memberships.

Design/methodology/approach
Employing a structured survey administered through Survey Monkey, the research methodically sampled professionals within the field. The investigation, conducted over a four-week period, sought to gauge the perspectives of individuals with diverse backgrounds, including both local and internationally experienced professionals. The study garnered 19 responses from a pool of 25 invitations and encompassed a wide range of participants, spanning recent graduates to seasoned professionals with nearly two decades of industry engagement.

Findings
Through an extensive review of existing literature and case studies, the paper underlines the positive impact of these associations on individual professionals, businesses, and the construction industry as a whole. The article concludes with recommendations on how to leverage these organizations effectively to foster continuous growth and innovation within the construction field.

Practical implications
The findings could potentially inform further research and recommendations, including seeking the AIB's current perspectives on membership dynamics, considering historical concerns regarding the cost-benefit ratio of membership dating back to 2012-2015.

Limitations
The study's limitations include its focus solely on the Australian construction industry and the use of a relatively small sample size. Due to these constraints, the generalizability of the findings to broader contexts or larger populations may be limited.

What is original/value of paper
The study's focus on a relatively overlooked area (the construction industry) within the realm of professional associations contributes to the existing body of knowledge, offering a nuanced understanding of the issues and opportunities unique to this sector. The findings can serve as a foundation for future research and strategic planning within both the construction industry and other professional sectors, enhancing the effectiveness and inclusivity of professional associations globally.

Keywords: Professional association, professional institutes, construction industry, membership
1. INTRODUCTION

The role played by the construction industry is vital as it affects productivity and well-being and provides the necessary infrastructure for all other industries function, yet the industry is often overlooked (CIOB, 2020; CIDB, 2021). The construction industry is very labour intensive, providing about 1 million jobs nationwide, of which 400,000 were in the formal sector in 2015 (African Competition Forum, 2019). By the second quarter of 2017, the sector employed around 965 000 people in the formal sector and a further 430 000 in the informal sector (i.e., total employment of 1 395 000 people) (Construction Industry Development Board, 2017). As economies progress from low-income to middle-income and eventually to high-income states, the construction sector's dynamics and contributions undergo significant transformations (Anaman & Osei-Amponsah, 2007; Oladinrin, Ogunsemi & Aje, 2012; Isa, Jimoh & Achenu, 2013). The construction domain encompasses a myriad of entities and functions vital for manifesting the built environment. This spectrum encompasses, clients or employers, builders (contractors, subcontractors and their workers, both skilled and unskilled), suppliers (machinery and equipment, and material suppliers), and construction professionals (e.g., architects, engineers, and surveyors). In a narrower context, the construction sector refers to firms and processes engaged in erecting and maintaining physical infrastructure. The distinction between developed and developing economies is particularly pronounced, with the former largely domestic-focused while the latter engages in international interactions due to a pronounced dependence on foreign inputs, including technology, materials, and contracting (Chinowsky & Molenaar, 1999; Hillebrandt, 1988; Manseau & Seaden, 2001; Boadu et al., 2020; Paul et al., 2019).

Historically acknowledged as an enabler of industrialization, urbanization, and transportation expansion, the construction sector wields a pivotal influence in shaping and advancing societal development. Construction is a critical sector in economies because it builds and maintains the infrastructure on which almost every other industry depends. Beyond facilitating trade and investment, construction infrastructures serve as conduits for the diffusion of technological advancements across developed and developing regions. Furthermore, the sector proves indispensable for post-conflict and post-disaster reconstruction efforts, underscoring its role in restoring socio-economic equilbrium (Amaratunga & Haigh, 2010; Ruddock et al., 2010). The reconstruction endeavours undertaken post the 2004 Indian Ocean tsunamis in Sri Lanka bolster the extensive impact of the construction sector's intricate connections within the economy (Ruddock et al., 2010). Additionally, the construction sector plays a substantial role in cultivating disaster resilience and management strategies, thereby contributing to the establishment of societies well equipped to withstand and recover from calamities (Haigh & Amaratunga, 2010). Concisely, the construction industry’s impact encompasses social, environmental, political and economic impact.

Central to growth theories is the consensus regarding the pivotal role of investment, encompassing construction activities, in driving economic growth (Solow, 1956; Griffiths & Wall, 1999; Dlamini, 2012; Daniele, 2017; Thong & Hao, 2019). Given its distinctive attributes and magnitude, the construction sector remains a prominent topic in public policy dialogues. The intricate relationship between the construction sector and GDP has consistently garnered attention from academic, governmental, and supranational entities since the 1970s (Hillebrandt, 1988; Wong et al., 2008). As a result, policies governing the construction sector invariably reflect a nation's socio-political, economic, and technological values. In this context, the significance of professional bodies within the construction industry emerges as a crucial facet. These associations play a pivotal role in
fostering industry standards, knowledge dissemination, skill development, and collaboration among construction professionals. Their influence extends beyond national borders, contributing to the harmonization of practices and the enhancement of the global construction landscape. By upholding ethical standards and promoting best practices, professional bodies contribute to the sector's growth, resilience, and adaptability in a rapidly evolving world.

2. LITERATURE REVIEW

2.1.1 Challenges Faced by the Construction Industry

The construction industry grapples with a range of challenges, in South Africa, this is evidenced by the CIDB reports (2004; 2021). The skills being channeled into the market via the Further Education and Training (FET) System are often ill-suited to the demands of the industry. Consequently, this mismatch between the skills supplied and the industry's requirements creates a substantial skills gap, which, in turn, diminishes the capacity of the professional sector operating within the construction field. This issue has a cascading effect, contributing to a decline in the overall quality of expertise available. Furthermore, as highlighted by van Wyk (2003), a critical challenge persists in the form of a significant proportion of industry participants lacking any form of education, including formal degrees. This prevailing situation serves as a substantial obstacle to the construction industry's progress and development. The absence of education and degrees within a notable portion of industry participants hampers the sector's ability to achieve higher standards of competence and professionalism. The large value of construction projects as well as the lumpy or infrequent nature of demand leaves constructions sectors around the world vulnerable to corruption and anti-competitive conduct (African Competition Forum, 2019). The construction industry is consistently ranked as one of the most corrupt industries worldwide. The impact of corruption goes beyond bribe payments to poor-quality construction of transport infrastructure with low-economic returns alongside low funding for maintenance (Kenny, 2008).

According to (Rodman and Lenssen, 2000), the construction industry accounts for a substantial share of global resource utilization. It represents one-sixth of the world's freshwater withdrawals, one-quarter of its wood harvest, and two-fifths of its material and energy flows. Additionally, the impact of structures extends beyond their immediate locations, influencing watersheds, air quality, and transportation patterns in neighboring communities. Neglecting considerations of energy efficiency, environmental impact, and natural resource conservation during construction can lead to wasteful practices that undermine ecological integrity (Hann and Tam 2002). Furthermore, it is noted that over half of all resources consumed worldwide are attributed to the construction sector, with an additional 45% of global energy production dedicated to heating, lighting, and ventilating buildings, along with 5% allocated to the construction process itself (Edwards 2002).

The successful completion of a project within its allocated budget is a pivotal criterion for project success. However, it is regretfully observed that a substantial number of projects do not meet this objective, experiencing budget overruns. This issue is prevalent not only in developed countries but also in developing nations, where budget overruns can sometimes surpass 100% of the initially estimated project cost (Azhar et al., year). Within the construction industry of the United Kingdom (UK), a significant proportion of clients have expressed dissatisfaction, with nearly one-third reporting that their projects frequently exceed the allocated budget (Jackson 2002).

Collectively, these challenges underscore a multifaceted landscape within the construction industry. The misalignment between available skills and required competencies poses a pressing concern, contributing to a skills gap and a compromised professional sector. Simultaneously, the prevalence of participants with limited or no education impedes the sector's advancement. Addressing these challenges is crucial to enhancing the construction industry's efficiency, efficacy, and overall contribution to economic and societal development. The
contemporary advancement of global industries is confronted with a formidable obstacle in the form of climate change. Tackling overarching concerns such as sustainability, the escalation of global temperatures (as manifested in CO2 emissions from both under-construction and operational buildings), and the judicious employment of water and other finite resources mandates stringent prerequisites that may pose challenges to stakeholders within the construction sector (UNIDO, 2009; van Wyk, 2004). Within this context, Ofori (1990) asserts that when ventures encompass novel technological frontiers, individual contractors might encounter limitations in their capacity to undertake such endeavours.

The definition of the construction industry often falls short, with inference being often made on activities on a construction site only, while overlooking professional services rendered and any materials manufactured offsite, with the former classified as services and the latter as manufacturing (CIOB, 2020).

2.1.2 Role of Professional Associations and Institutes

The built environment is made up of a diverse array of experts, including architects, engineers, quantity surveyors, estate surveyors, land surveyors, and town planners. The value addition provided by these consultants is regarded as services and the professionals’ conduct and undertakings in delivering these services are subject to the oversight of professional associations or institutions. These bodies consist of individuals within the same field, united with the explicit purpose of attaining specific objectives, providing services, and fostering the professional growth of their members. Obaju et al. (2022), noted that the presence of professionals in construction projects stands out as one of the most crucial factors for achieving successful project delivery. The services provided by professionals in the construction industry play a significant role in advancing the services sector and boosting the economy towards higher income levels (Ibid).

Professional bodies have been described as assemblies of individuals whose perspectives on sustainable development are shaped by their educational backgrounds, professional know-how, and interactions within their field (Oni, 2015; Obaju et al., 2022). These professional bodies exercise oversight over professionals through prescribed codes of ethics and conduct. Within the built environment, a collection of professional institutions and regulatory bodies collaboratively work to ensure the effective provision of construction industry buildings and infrastructure. These institutions confer legitimacy and influence to built environment professions, serving as platforms for idea exchange, camaraderie, and advocacy. They have also transformed into repositories of knowledge, disseminating insights, ideas, and information to professionals and stakeholders in the construction industry (Shetan, 2018). The role of some professional institutions involves certifying qualifications and licenses, while others focus on upholding ethical standards within their respective domains (Shetan, 2018). Regulatory bodies, governed by relevant Acts, guide the activities of professional associations and empower them to establish rules that govern their members’ conduct. To practice within the industry, professionals must secure approval from registration boards, thereby adhering to regulatory standards (Shetan, 2018).

The significance of professional institutions in the construction industry extends to knowledge cultivation and elevation of professional standards (Green, 2015). These bodies promote best practices, disseminate the latest advancements, and even manage educational institutions to ensure that their curricula remain attuned to the evolving demands of the industry (Green, 2015; Ogunbiyi, 2015). Ogunbiyi (2015) underscored that challenges arise when graduates and trained personnel struggle to become registered members of their professional bodies. This void can lead to subpar practices, inadequate standards, and a proliferation of unqualified practitioners. This predicament is exacerbated by a dearth of young professionals entering the industry, resulting in an aging workforce without sufficient successors (Borg et al., 2021; PMI, 2018). In response
to this exigent situation, the construction industry faces the pressing imperative of cultivating a qualified and replenishing workforce capable of driving transformative change in the years ahead (Borg et al., 2021; PMI, 2018). To confront these forthcoming challenges, it is essential for the construction industry and its affiliated professional institutions to effectively attract, retain, and develop a robust contingent of professionals (Borg et al., 2021; PMI, 2018).

3. METHODOLOGY

This study adopted a descriptive research design, aiming to provide a detailed and systematic analysis of the research questions. The survey instrument was constructed based on one of the researchers’ prior experiences as the Chair of Membership for the Australian Institute of Building (AIB). The primary research objective was to gather opinions on the relevance of professional institutes within the construction management and economics field, particularly in the context of concerns over stagnating or declining AIB membership. Additionally, the study examined the role of industry stakeholders in promoting professional institute memberships and explored the financial considerations associated with such memberships.

Purposive sampling, a non-random selection technique, was employed to recruit participants for this research. The selection process relied on the researcher’s extensive professional network in Australia. The target population comprised individuals actively engaged in the professions of construction management and economics. To ensure a comprehensive representation of viewpoints, invitations were extended to professionals both residing in Australia and those with international affiliations, stemming from their early career experiences outside of Australia. This deliberate approach to participant selection aimed to capture a diverse array of perspectives within the chosen field.

A structured survey, administered through Survey Monkey, served as the primary data collection method. The research systematically sampled professionals within the field over a four-week duration, providing ample time for participants to provide their valuable insights. The study successfully obtained 19 responses from a pool of 25 invitations, encompassing a broad range of participants, including recent graduates and seasoned professionals with nearly two decades of industry engagement.

4. FINDINGS AND DISCUSSIONS

4.1 Professionals that are members of an association.

19 of the responses received indicated that they were currently members of a professional association or institute. When further prompted on which institute they were a member of, their responses are as outlined below.

<table>
<thead>
<tr>
<th>Institute</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Institute of Building - AIB</td>
<td>13</td>
</tr>
<tr>
<td>Australian Institute of Quantity Surveyors - AIQS</td>
<td>4</td>
</tr>
<tr>
<td>Engineers Australia - EA</td>
<td>4</td>
</tr>
<tr>
<td>Australian Institute of Architects - AIA</td>
<td>2</td>
</tr>
<tr>
<td>Australian Institute of Building Surveyors - AIBS</td>
<td>1</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total respondents</strong></td>
<td><strong>19</strong></td>
</tr>
</tbody>
</table>

Table 1: Australian Affiliation
Table 1 provides an overview of the affiliations of 19 respondents in the field of construction management and economics in Australia. The data indicates that the Australian Institute of Building (AIB) has the most prominent affiliation, with 13 respondents, signifying its significant presence within the industry. The Australian Institute of Quantity Surveyors (AIQS) and Engineers Australia (EA) both have four respondents each, demonstrating substantial representation. The Australian Institute of Architects (AIA) and the Australian Institute of Building Surveyors (AIBS) have two and one respondent, respectively, reflecting more specialized affiliations. Additionally, four respondents mentioned affiliations with "Other (international)" organizations, highlighting the global dimension to some respondents' professional connections.

Overall, the data reflects a diverse landscape of professional institute affiliations among construction management and economics professionals in Australia. The dominance of AIB in the responses suggests its significant role in this industry. Additionally, the presence of professionals affiliated with other organizations like AIQS, EA, AIA, and AIBS showcases the varied opportunities for professional development and networking within this field.

4.2 Professional Development

When probed as to whether the stated institute engages its members, 14 out of the 18 respondents responded affirmatively. Based on the data collected from the survey, here are some concrete interpretations and insights related to professional associations:

Membership Rates: A significant majority of respondents, around 89.47%, indicated that they are current members of professional associations or institutes. This suggests a strong interest and participation in these organizations within the surveyed group.

Association Relevance: The data shows that a majority of respondents (72.22%) are members of Australian professional associations or institutes, such as the Australian Institute of Building (AIB), Australian Institute of Quantity Surveyors (AIQS), Engineers Australia (EA), and others. This indicates that professionals find value in these associations related to their respective fields.

International Engagement: Around 7.69% of respondents reported membership in overseas professional associations or institutes, which indicates some level of international networking and engagement among the surveyed individuals.

Event Participation: A considerable number of respondents (77.78%) reported that they regularly attend events hosted by their professional associations or institutes. This suggests that these organizations are successful in providing valuable events that members find worthwhile.

Association Engagement: A significant portion of respondents (77.78%) indicated that their professional associations or institutes engage with their members, implying active communication and involvement.

CPD Opportunities: The majority of respondents (63.16%) reported that their professional associations or institutes host relevant Continuous Professional Development (CPD) events. This suggests that these organizations are seen as valuable sources of ongoing education.

CPD Record Checking: A majority of respondents (63.16%) reported that their professional associations or institutes regularly check their CPD records. This indicates an emphasis on maintaining professional development standards within these associations.
Employer Valuation: Around 73.68% of respondents indicated that their employers value their membership in professional associations or institutes. This suggests that employers recognize the benefits and contributions that membership brings to their employees' professional growth.

Employment Benefits: A notable portion of respondents (47.37%) reported that membership in their professional association or institute helped them gain their current employment. This highlights the role these organizations play in career advancement.

Profession Promotion: Around 47.37% of respondents stated that they promote their profession amongst their colleagues. This indicates that members feel a sense of responsibility to advocate for their field and raise awareness among peers.

These insights resonate with the concepts highlighted in the literature. Oni (2015) described professional bodies as gatherings of individuals shaped by their education and professional experiences, with oversight provided through ethical codes. These associations serve as repositories of knowledge and platforms for exchange (Shetan, 2018). Furthermore, professional institutions play a vital role in cultivating knowledge and upholding standards within the construction industry (Green, 2015; Ogunbiyi, 2015). However, challenges arise when professionals struggle to join such associations, potentially leading to subpar practices (Ogunbiyi, 2015). To address these challenges, the construction industry must attract, retain, and develop a skilled workforce, aligning with the significance of professional institutions (Borg et al., 2021; PMI, 2018).

These findings underscore the importance of professional associations in the construction industry's growth and development, aligning with the insights shared in the literature. The collaboration between these associations and industry practitioners is crucial for addressing challenges and driving positive change in the years ahead. In conclusion, the survey data demonstrates that professional associations serve as valuable resources for professional growth and advancement.

5. CONCLUSION
In conclusion, the literature and survey findings underscore the pivotal role of professional associations in the construction industry. These associations, acting as repositories of knowledge and ethical standards, are essential for the growth and development of professionals. The challenges highlighted, particularly the difficulty in joining such associations, call for urgent attention. However, the engaged and valued memberships among respondents demonstrate the significance of these associations in fostering professional growth and advancement.

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Emergence of the construction mafia in South Africa

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ABSTRACT AND KEYWORDS

Purpose of this paper
In recent years’ South Africa has observed the development of a novel kind of criminality in the form of systematic organised groups targeting the construction industry under the term of ‘radical economic transformation’. Therefore this paper aims to identify the impact of the construction mafia on the construction industry.

Design/methodology/approach
An extensive literature review was carried out to identify the evolution and impact of the construction mafia in the South African construction sector.

Findings
Findings revealed that the so called ‘construction mafia’ played a major role in contributing towards the closure of many construction companies around the country. In addition, these criminal activities of the construction mafia have been driven by the faint response from government thereby enabling the activities to continue.

Research limitations
There is a lack of data with regard to quantifying the number of construction companies that have been affected by the construction mafia.

What is original/value of paper
Data regarding organised crime is limited therefore this paper will contribute to the growth of research on this topic.

Criminality, Construction, Construction mafia, Novel, Transformation
1. THE SOUTH AFRICAN CONSTRUCTION INDUSTRY
The South African construction industry is a fundamental driver of socio-economic development and plays a vital role in the country’s economic growth. The industry is significant as it promotes the prosperity of a nation (Berk & Biçen, 2017). In South Africa, the industry employed over 1.2 million people in 2021. It was further reported that the industry contributed around R111 billion towards the country’s gross domestic product (GDP) (South Africa Construction Market Report 2022; StatsSA, 2021).

However, despite the significant importance and the sector being regarded as a national asset by the South African government, the industry is under siege (Renault et al., 2018). Construction companies throughout the country are consumed by the ongoing protest action by so-called groups often accompanied by physical harm, violence and destruction of construction works (GITOC, 2022). The rise of these so-called colloquial groups labelled as the ‘construction mafia’ occurred when the outcomes of disruptions in the Kwazulu-Natal construction sites was fruitful (eNCA, 2022) Consequently, this phenomenon has now spread to sites across the country with these groups violently demanding 30% of the project value either by making contractors employ their workforce, their subcontractors or by procuring materials from network controlled by the mafia. Predictably, the cost of materials procured through the mafia is uncompetitive and inflated. The financial impact on construction projects is significant due to the resultant work stoppages, project delays and escalating project costs. In addition, members of the project team are persistently threatened with rifles and firearms. Consequently, in some instances construction projects are terminated as a result of the ongoing disruptions as contractors find it increasingly challenging to continue to fulfil their contractual obligations (Rondganger, 2016).

2. BACKGROUND
2.1 Organised construction crime
Criminologists have identified organized crime as a criminal and illegal activity to obtain, directly or indirectly, a financial or material benefit by groups or networks that participate in life-threatening violence and penetration of the legitimate economy through racketeering, money-laundering and extortion (Chan & Owusu, 2017; GITOC, 2022; Sohail & Cavill, 2008; Tabish & Jha, 2012). Extortion is a crime where a person forces another to do something against their will under threat, engaging in violence or property damage (Di Gennaro, 2016; Garofalo et al., 2016). Further, it was highlighted there are two types of extortion; casual extortion which occurs as a sporadic once off event and systematic extortion that occurs as a continual practice. Although these extortion practices are dubbed under the term ‘radical economic transformation’, they have in fact affected both white-owned and black-owned companies indicative of these activities being carried out under false pretences and in reality on the basis of monetary gain (Albanese, 2021; Cokayne, 2021; Piemontese, 2020; Rusev, 2018; Scandizzo & Ventura, 2015).

The Association of South African Quantity Surveyors (ASAQS) has called for government to step in to protect infrastructure projects, investor confidence, and the safety of built environment professionals working on construction sites (Heever, 2019). In a report the South African Forum of Civil Engineering Contractors (SAFCEC) highlighted that construction sites with an estimated value of R27.5-billion have been violently disrupted or halted in South Africa in recent years (Donnelly, 2019). In addition, it was noted that the unrest observed at construction sites is driven, to a degree, by the desire of the surrounding communities to become involved in and gain economically from projects in their area. These expectations are genuine and cannot be dismissed and have to be met. On the other hand, violence is driven by mafia-style gangs which are often linked to political figures. Currently there are very few public sector projects in parts of the country that are not disrupted by these demands. Delays in starting projects and claims for additional time and costs associated with such activity are becoming the order of the day (Buthelezi, 2022; Durdyev & Hosseini, 2019). Contractors in hotspots have to incur additional and unbudgeted costs of security and protection of themselves, their workforce, their plant and equipment, their unfixed
materials and even uncompleted work. These additional costs are not covered in existing construction contract provisions.

2. 2 Insurrection of the construction mafia

In 2014, in the Umlazi township near Durban in the KwaZulu-Natal province a group of people came together and formed the Delangokubona Business forum. It was later identified that this forum comprised of ex-convicts that committed serious violent crimes such as cash in transit heists, murders and rapes. Around the same time in a different township known as KwaMashu, a group of people formed the Youth Action Movement (GITOC, 2022). These two groups targeted construction projects in their local area after merging to form the Federation for Radical Economic Transformation (FFRET). Subsequently, between 2016 and 2019 almost all construction sites within the province of KwaZulu-Natal faced disruptions by FFRET (Heever, 2019).

In May 2017 the construction mafia ventured out to disrupt business activities in the leading soft drink company, Coca-Cola Beverages South Africa (CCBSA). By 2018, the construction mafia activities had spread to the Gauteng province invading several construction projects. Additionally, the construction mafia had become a widespread challenge that the construction sector throughout the country had to face. In 2019 smaller replica groups formed in the Eastern Cape disrupting many sites, one of which was a joint venture between Aveng and German based Strabag International. The construction mafia halted works for more than 84 days and subsequently the project was terminated. SAFCEC CEO, Webster Mfebe highlighted the pattern of growth of the construction mafia across the country by claiming that: ‘Violence begets violence (Donnelly, 2019).’ Subsequently when people have seen that extortion methods achieve the desired outcome, they are encouraged to mimic the same tactics and strategies (Donnelly, 2019).

2. 3 Thirty percentile entitlement

The construction mafia finds its foundations ostensibly in the variation of the revised Preferential Procurement Policy Framework Act (5 of 2000) (PPPFA). The variation requires, inter alia, that bidders of any project value of R30 million or more to subcontract a minimum of 30% of the value of contract to Exempted Micro Enterprises (EMEs) or small businesses as defined in the National Small Business Act, 1996. The mafia advance the PPPFA under a degenerate mantra of radical economic transformation. However, the interpretation is flawed as the PPPFA pertains to governmental work only and not to private sector business. However, the construction mafia have used this to achieve both public and private sector work (GITOC, 2022). There is no legal basis underpinning the construction mafia’s demands on private sector businesses, as there is no obligation to accept extortionist demands. A report by The Global Initiative against Transnational Organized Crime revealed that in 2019, such disruptions affected at least 183 infrastructure and construction projects worth more than R63 billion in South Africa. Finance minister Enoch Godongwana further elaborated that the implementation of the regulation was aimed at increasing the level of local involvement in procurement. Additionally, Godongwana stated if a project exceeds R50 million, an allocation of 30% should be allocated to local content. Although, the regulation pertains to governmental work the construction mafia have used this to achieve both public and private sector work (Geldenhuys, 2022). While well-intentioned the emergence of the construction mafia is an unintended consequence of legitimate and deliberate efforts by government to increase local participation with the knock-on economic benefits for the beneficiaries.

3. METHODOLOGY

The study verified Scopus and science direct as a source of data due to their widespread coverage of global research publications (Hosseini et al., 2018). The databases used were considered as primary scientific research database (Olawumi & Chan, 2018). A comprehensive selection process was embraced to sieve pertinent
publications on the database and centred only on relevant publications in English. The retrieval of publications was undertaken on the 13th of December 2022, with 18 publications identified. In addition, a keyword search was undertaken to filter out unrelated publications, with keywords such as “Construction Mafia”, “Extortion”, “Mafia gangs”, “Organised crime”. Various combinations of the keywords were used in order to validate the range of the search results. The results of a search on different platforms reviewed 13 publications that were further filtered to 8 and 3 relevant publications were eventually referred to for the literature review.

4. RESULTS
4.1 Global organized crime
According to the global organized crime ENACT (2021) index statistics, a total of 193 countries were surveyed globally according to their levels of criminality on a scale of 1-10. Where 1-3 signifies little influence in which the actor type is either non-existent or negligible in their impact; 4-5 signifies moderate influence; 6-7 signifies significant influence and a score of 8-10 signifies severe influence, in which no aspect of society goes untouched by criminality (GITOC, 2022). Table 1 reflects South Africa achieved an overall 6.63 criminality score. South Africa was ranked 19th out of 193 countries globally and 1st out of the Southern African countries.

<table>
<thead>
<tr>
<th>World ranking</th>
<th>Southern Countries</th>
<th>African Criminality Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>South Africa</td>
<td>6.63</td>
</tr>
<tr>
<td>21</td>
<td>Mozambique</td>
<td>6.53</td>
</tr>
<tr>
<td>59</td>
<td>Zimbabwe</td>
<td>5.67</td>
</tr>
<tr>
<td>75</td>
<td>Angola</td>
<td>5.29</td>
</tr>
<tr>
<td>92</td>
<td>Zambia</td>
<td>4.93</td>
</tr>
<tr>
<td>130</td>
<td>Namibia</td>
<td>4.33</td>
</tr>
<tr>
<td>148</td>
<td>Lesotho</td>
<td>3.90</td>
</tr>
<tr>
<td>157</td>
<td>Botswana</td>
<td>3.72</td>
</tr>
<tr>
<td>162</td>
<td>Eswatini</td>
<td>3.36</td>
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</table>

The criminality score was determined based on the following criminal actors; Criminal networks, State embedded actors, Foreign Actors and Mafia styled groups. Mafia-style groups achieved a 7.00 score and is identified to be the drive behind high crime rates in particular involving drugs and extortion (ENACT, 2021).

4.2 Observations
There seems to be an inaccurate record of the number of construction sites that have been affected by the construction mafia either by project delays or project termination either voluntarily or by agreement with clients (Anon, 2022). It is believed that South African construction organizations have established a response task team to assist companies and sites that are affected. However, they are not adequately equipped and are unable to quantify the affected companies and sites. For example, in KZN various parties joined forces to form the Building Industry Steering Committee. These parties had recognised that it was critical for engagement between concerned
and affected parties to achieve the goal of business and development in a calm dignified manner. Outcomes of the meetings highlighted that several companies complained that the disruptions caused significant project delays. Companies that employed the mafia members and their workforce complained that the quality of workmanship was poor and rates were excessive. In addition, the disruptions in the industry were reported to have a negative impact on young students applying for industry related tertiary qualifications. Subsequently negotiations in bad faith by the construction mafia ultimately led to the demise of the committee (Anon, 2022).

A recent quantitative study carried out by Ngubane et al. (2022) titled “Causes and effects of delays in the implementation phase of infrastructure construction projects: Umgeni Water Case Study”, surveyed 116 contractual representatives, including contractors, clients and engineers working on past and current Umgeni water projects. The study found that disruptions by the construction mafia were a crucial factor. The mafia caused significant construction delays and a gap in the delivery of stakeholder requirements for projects. Ubisi (2022) highlighted that the corrupt activities of the construction mafia gangs hamper the construction industry and should be mitigated.

5. DISCUSSION

Construction companies around the country were affected by the activities of the construction mafia and as a result some sought to obtain court interdicts against the construction mafia as a prevention method. Fifty-one court interdicts were granted between 2016 and 2019 respectively. However these interdicts failed to restrict mafia-styled activities. Ryan (2018) noted that although companies procured and attained the court interdicts, the construction mafia continued to intimidate their workers (Qhobosheane 2022).

These gangs demand employment from the construction site at extortionate rates. It was identified in KwaZulu-natal that a company was forced into employing a bricklayer at more than three times the going market rate. Consequently companies were faced with the challenge of letting their workers go in order to make room for gang members who more often then not lacked the skillsets required for the job. It was further found that materials and equipment were stolen from sites when mafia members are employed. There seems to be a sluggish response by government to the threat to the industry as a whole and as a result many companies have taken the responsibility to address the issue themselves. This meant hiring private armed security personnel at an added cost while trying to recover these unanticipated costs from clients, usually without success (Thamm, 2021).

The construction mafia significantly contributed to accelerating the demise of certain construction companies and driving others to the brink of bankruptcy (Ndaba, 2022). According to the SAFCEC CEO some of the larger construction companies have been able to survive by pursuing work outside South Africa’s border. However, many of the smaller companies have been forced to shut down. Construction sites have been vandalized and damaged during the disruptions and as a result incurred considerable added costs. The impact was increasing company overheads for projects and delays in delivering critical infrastructure, that collectively undermine service delivery and economic development (Durdyev & Hosseini, 2019; Marriah-Maharaj, 2022).

In 2018, the South African National Road Agency (SANRAL) indicated that several of their projects have been disrupted and some projects delayed for months. In August 2017, SANRAL delayed the rollout of new projects due to the high risk posed to contractors’ workforces and property. As a result posing a significant impact on the economy as well as the outcome the construction mafia’s behavior poses on professionals safety and wellbeing (Maduray, 2022; Slabbert, 2018). The ASAQS and SAFCEC reported that more than 110 engineers and skilled personnel had left the country as a result of the activities of the construction mafia (Heever, 2019). Unskilled labour working on construction sites do not have the opportunity to migrate, as a result they are forced to work under fear with constant disruptions on sites by the construction mafia. Additionally, these unskilled workers who desperately need the work to earn an income to survive are constantly faced with the insecurity of being physically hurt or retrenched (Moneyweb, 2018; Ryan, 2018).

While there are several contributing factors pertaining to the implications of disruptions and violence as an
outcome of the construction mafia it seeks to question if contracts are equipped to deal with matters such as the construction mafia accordingly. In a report by Reyneke (2018) based on a case, a court judgment handed down to SANRAL’s appointed joint venture (JV) employee working on the flyover interchange in Springfield Durban, it was identified that the JV felt SANRAL was responsible to pay for the additional costs of security to the value of R926 000. Additionally, the violent disruptions constitutes a force majeure, therefore the JV was eligible to claim release from the contract.

The project was under the FIDIC contract and as a result the contract defines force majeure as:

“…an exceptional event or circumstance:

a) which is beyond a Party’s control,
b) which such Party could not reasonably have provided against before entering into the Contract,
c) which, having arisen, such Party could not reasonably have avoided or overcome, and
d) which is not substantially attributable to the other party”

In addition, the contract highlights that should a matter arise making it unlawful or impossible for either party to fulfil their contractual requirements the parties are eligible for release of future performance. However the court identified the disruptions of the construction mafia not a force majeure circumstance (Watermeyer & Phillips, 2020). Subsequently in order for it to be force majeure the JV was tasked to prove that the matter is in fact beyond their control. Furthermore, the judge found that there appeared to be no purpose as to why with the additional payment of R926 000 per month the challenges faced could not be resolved (Watermeyer & Phillips, 2020).

6. CONCLUSIONS

There is a significant need for more and better statistics on organized crime and extortion in order to fight against transnational organized crime in the South African construction industry. There seems to be a lack of information as construction companies prefer not to report extortionist activities due to threats to their company and family. In addition, the governments slow response to the establishment of the construction mafia during the foundational stages makes it almost impossible to terminate these gangs. Unfortunately, these criminals understand that their extortionist behaviour reaps no repercussion and has no consequences. The temporary solution followed by construction sites invaded by the mafia is to obtain urgent interdictory relief from the high court. However unfortunately this action still places a severe financial strain on the project as companies are required to pay standing fees even while the project is at a halt. It is suggested that government be more involved and develop concise and effective strategies to address extortion activities. Additionally in South African there seems to be no common law definition of “Force Majeure” therefore this should be written into the contract prior to commencement of work. The ongoing ignorance of these groups by the state will result in dire consequences not only for the construction industry but for the entire country.

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Challenges encountered in implementing maintenance strategies in public health facilities: A case of Limpopo Province

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ABSTRACT

Purpose
Public health facilities are critical for enhancing healthcare services to the citizens of any country. They contribute to facilitating the recovery of patients and enhance productivity for medical and support staff. However, public health facilities in South Africa are facing poor maintenance, exacerbated by a lack of maintenance and proper implementation of maintenance strategies. There is a shortage of research addressing the challenges experienced in the implementation of maintenance strategies in public hospitals in Limpopo. Therefore, this paper aims to identify the factors preventing the implementation of maintenance strategies in public health facilities in the Limpopo province.

Methodology
The qualitative approach was adopted to achieve the aim of the study. Data were collected using a semi-structured interview. Nineteen (19) purposively sampled respondents participated in the interviews. The data were recorded and transcribed. Thematic analysis was employed to identify and analyze the challenges.

Findings
The challenges identified in this research that deter the implementation of maintenance strategies include a lack of manpower, elderly staff, unskilled labourers, staff and material shortages, financial constraints, delays in the procurement process, poor infrastructure, limited transportation, and low-quality building materials.

Limitation
The study only focused on public health facilities in Limpopo province; therefore, the findings cannot be generalized to the entire country or to private hospitals.
Practical implication
The findings of this study can be adopted by policymakers in the PHF sector to improve the implementation of their maintenance strategies. The research outcome can be implemented to boost the productivity of medical and support staff, ultimately leading to improved patient recovery.

Value
Although several studies have investigated maintenance strategies for various facilities in Limpopo, South Africa, there is a dearth of research addressing maintenance strategies for PHFs in this region.

Keywords: Challenges, Limpopo, maintenance strategies, public healthcare facilities, South Africa
1.0 INTRODUCTION
Public healthcare facilities in South Africa are crucial for the citizens who rely on them. Implementing maintenance strategies is imperative to preserve and extend their lifespan. To achieve this goal, the National Infrastructure Maintenance Strategy was developed and approved by Cabinet \(^1\). It aims to ensure that all state organizations maintain public-owned facilities and infrastructure effectively. The government continues to emphasize adequate planning for maintaining public health facilities, including hospitals and clinics. This ensures that these facilities remain in good condition for both employees and patients.

Poorly maintained buildings deteriorate over time due to inherent design flaws, construction defects, and the impact of the climate \(^2\). Dilapidated public healthcare facilities in the Limpopo Province pose safety risks and health hazards to both employees and patients \(^3\), \(^4\), in his publication, reported that the Limpopo health system is deteriorating, with public health infrastructure facing severe maintenance challenges that lead to building dilapidation. \(^5\) highlighted that existing public health facilities are in poor condition due to a lack of maintenance and the improper implementation of maintenance strategies. Patients and nurses have confirmed that certain departments have an inadequate physical environment for delivering quality healthcare \(^6\). Some public healthcare facilities are so old and deteriorated that they require replacement.

Public healthcare facilities in the Department of Health in Limpopo (DoHL) province are part of the provincial government buildings, budgeted for maintenance annually. In the 2021/22 fiscal year, the Department of Health had an allocation of R760 million for infrastructure programs, including COVID-19-related initiatives, hospital revitalization, clinic construction and upgrades, and building and equipment maintenance. Unfortunately, during the fiscal year, they encountered interferences that led to deferred maintenance due to financial constraints. \(^7\) identified six barriers to the implementation of maintenance strategies, often referred to as “killers,” including top-down senior management style, inconsistent planning, competing agendas, an inefficient senior management team, weak vertical communication, poor teamwork across roles and company borders, and insufficient leadership skills and growth at lower levels.

\(^8\) identified maintenance challenges in tertiary hospitals in Southeast Nigeria, highlighting that even though tertiary hospitals have maintenance schedules, they are not consistently followed, and maintenance occurs only when critical equipment breaks down. They also questioned the competence of tertiary hospital maintenance staff, especially in emergencies, and noted that these units are often understaffed. Factors affecting maintenance decisions included the misuse of buildings after construction, defective designs, a lack of skilled workers and unqualified maintenance contractors, inadequate financial support, and a failure to implement preventive maintenance \(^9\).

To overcome these barriers and implement effective maintenance strategies, \(^10\) identified five critical success factors (CSFs): program simplicity, effective maintenance, cost allocation budgeting, use of suitable techniques, risk management in maintenance work, and communication and information flow. \(^11\) identified CSFs for building maintenance management from four perspectives: customer, internal processes, financial, and learning and growth perspectives. However, despite the CSFs and the barriers identified in various studies, there appears to be a lack of consensus in the literature. Furthermore, there is a dearth of studies that have specifically focused on the challenges preventing the implementation of maintenance strategies. This study aims to identify the challenges faced by the DoHL in implementing its maintenance strategies.

2.0 LITERATURE REVIEW
The identified key barriers to effective total productive maintenance, include lack of long-term
commitment from top management, a shortage of qualified personnel, insufficient staff buy-in, an increasing workload for employees, resistance to cultural change, and inadequate communication awareness. It has been noted that most public sector institutions lack the means to address all their maintenance problems, resulting in a backlog of new infrastructure provisions. He further observed that strategic infrastructure, including wastewater treatment and healthcare facilities, is often inadequately maintained due to budget constraints.

The importance of considering maintenance policy within the broader organizational policies of healthcare facilities in Ghana. Neglecting maintenance policy can lead to higher costs when damage in buildings or equipment is ignored until it results in complete breakdowns.

The outlined challenges encountered by maintenance departments, such as the age of buildings, building finishes, materials, and vandalism. These challenges significantly impact maintenance strategies, leading to increased costs for organizations. Maintenance management in hospital facilities is recognized as a vital factor in achieving peak efficiency and sustainability. Neglected maintenance not only incurs costs for the government and the public but also reflects poorly on maintenance culture, particularly among visitors from other countries. It has been stated that poor maintenance is a pervasive issue in Ghana, often viewed as a wasteful endeavour and a misuse of resources. This resistance poses challenges for maintenance teams seeking resources from leaders and management to ensure effective maintenance.

In a hospital environment, maintenance serves the critical purpose of achieving error-free operations, especially in areas where small errors can have significant repercussions and be a matter of life and death. The extensive network and range of activities required to maintain healthcare operations, along with the complexity of services needed to support them, present major challenges in managing healthcare facilities. Budget constraints, high expenditures, service criticality, customer satisfaction, complex information, and decision-making all influence the implementation of maintenance strategies in healthcare facilities. The significant complexity of hospital buildings, the high criticality of mechanical and electrical systems, and limited maintenance funding make it difficult for maintenance teams to fulfil their duties. Other factors that influence the performance and operation of hospital facilities, include the age of buildings, building surroundings, managerial resources, and labour sources for maintenance, whether provided in-house or outsourced. Maintenance effectiveness contributes to increased income by enhancing equipment performance and plant capacity. The effectiveness of building maintenance management and government asset management is critical in ensuring that all government entities operate in the public interest.

3.0 RESEARCH METHODOLOGY

The aim of this paper was to identify the factors preventing the implementation of maintenance strategies in public health facilities in the Limpopo province, South Africa. We adopted purposive sampling for this study because it was designed to select participants actively involved in maintaining hospitals and clinics in the Limpopo Province. To ensure a credible sample size, we followed the recommended guidelines, which suggest a minimum sample size of 5 and a maximum of 20 for interviews would derive data saturation.

As a result, we conducted interviews with a total of nineteen participants from public healthcare facilities in Limpopo province. This included one senior maintenance manager and four maintenance technical staff responsible for electrical, mechanical, horticulture, and civil/building activities from each healthcare facility who willingly participated. We collected data using semi-structured interviews and recorded them. Subsequently, we employed thematic analysis to identify the main themes and sub-themes of the challenges. To ensure the trustworthiness of our research, we took several measures, including recording the interviews, maintaining an...
4.0 RESULTS AND DISCUSSION

Socio-demographics data of participants

The sociodemographic characteristics of the respondents are summarized in Table 1. Among the participants, two individuals (10.53% of the total respondents) hold a National Diploma qualification. Eight respondents (42.11%) have a National N6 Diploma, while two (10.53%) possess a National N Certificate. Additionally, seven respondents (36.84%) hold certificates. Regarding specific qualifications, one respondent has an architecture qualification, two possess horticulture qualifications with building maintenance skills, six hold building qualifications, five have electrical qualifications, and five have mechanical qualifications. One respondent is professionally registered with the South African Council for Architectural Profession (SACAP), while the remaining eighteen are not professionally registered.

The participants were drawn from various employment levels, with five of them (26.32% of the total respondents) serving as Chief Artisans or maintenance managers. Two participants (10.53%) held positions as Horticulturist Supervisors with building maintenance skills, while seven (36.84%) were appointed as artisans. An additional five participants (26.32%) were tradesman-aids. All respondents are actively involved in general building maintenance work for healthcare facilities. Their responsibilities encompass tasks such as small building renovations, mechanical work related to air conditioning, standby generators, boilers, calorifiers, and theatre machines, as well as horticulture for landscaping and electrical work involving lights, theatre equipment, and transformers. Participants were asked to disclose their years of work experience in maintaining public healthcare facilities. The range of work experience varied from a minimum of 2 years to a maximum of 37 years.

Table 1 The participants’ demographic traits

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<thead>
<tr>
<th>Respondents’ Profile</th>
<th>No of staff = n</th>
<th>T = n / 19 x (100)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highest Academic Qualification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Diploma</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>National N6 Diploma</td>
<td>8</td>
<td>42%</td>
</tr>
<tr>
<td>National N Certificates</td>
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<td>11%</td>
</tr>
<tr>
<td>Certificates</td>
<td>7</td>
<td>37%</td>
</tr>
<tr>
<td><strong>Professional Council</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SACAP</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Roles played by participants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance manager</td>
<td>5</td>
<td>26%</td>
</tr>
<tr>
<td>Supervisors</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>Artisan</td>
<td>7</td>
<td>37%</td>
</tr>
<tr>
<td>Tradesman aid</td>
<td>5</td>
<td>26%</td>
</tr>
<tr>
<td><strong>Years of Experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-10 Years</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>10 – 20 Years</td>
<td>15</td>
<td>79%</td>
</tr>
<tr>
<td>More than 20 years</td>
<td>3</td>
<td>16%</td>
</tr>
</tbody>
</table>

CHALLENGES ENCOUNTERED IN IMPLEMENTING MAINTENANCE STRATEGIES IN LIMPOPO DOH

Figure 1 illustrates the main themes and challenges that were identified. The participants identified the
challenges encountered in their endeavor to implement maintenance strategies in the Department of Health in Limpopo. These challenges, as identified by the participants, are summarized herein: a lack of manpower, elderly staff, unskilled laborers, staff and material shortages, financial constraints; delays in the procurement process, poor infrastructure, lack of transportation, and poor quality of building materials.

**Figure 1 Barriers to implementing maintenance strategies**

**Lack of Manpower**

The quality of services provided to hospitals in Limpopo may be significantly impacted by the persistent lack of and questions about the competence of labor in facilities and maintenance. Participant 1 (P1) expressed this concern: 'We do not have enough employees like artisans, tradesmen, and groundsmen.' The shortage of staff affects planning, as noted by P1, P5, P6, P7, and P9. Participant 7 mentioned the difficulty in completing tasks and ensuring that hospital facilities meet the required standards because they often have to seek assistance from workers in other departments, such as plumbing or horticulture, for electrical work.

This issue is supported by 19 when they stated that obstacles to successful building maintenance include a lack of resources, a shortage of maintenance staff, and insufficient support for these individuals. Furthermore, 20 emphasized the vital importance of having both high-quality and sufficient local human resources in the construction sector to maintain global competitiveness. Adding to this, 19 noted a shortage of maintenance staff, their lack of technical expertise, insufficient funding, and a lack of incentives for them to perform their tasks effectively. They also observed that the availability of trained and competent construction and maintenance professionals was a significant factor that would impact the quality of maintenance operations.

**Elderly Staff**

A downside of having senior or aging workers in the maintenance department is their difficulty in lifting...
heavy objects or climbing step ladders, as noted by P14. Furthermore, maintenance work is labour-intensive, and we currently have older employees who are nearing retirement (P14). Some responsibilities involve strenuous physical labor, while others require indoor and outdoor work. This finding aligns with the observations made by 21, who pointed out that an increasing proportion of workers in the construction industry are fifty (50) years of age or older. They also highlighted the impacts of this aging trend on the construction industry, including a significant decline in employee productivity due to aging, health issues, safety concerns, and well-being challenges, as well as a labor shortage. These circumstances, coupled with various organizational and institutional shortcomings in the industry that create an unfavorable work environment, not only negatively affect the construction industry's economic viability but also give rise to additional psychosocial problems faced by older workers.

Unskilled Personnel

Maintenance tasks require skilled personnel to ensure that facilities are well-maintained and meet the necessary standards. However, respondent P17 mentioned that there is a lack of skilled personnel: 'The workforce does not meet the required standard of work, as some individuals are appointed without relevant expertise and qualifications.' These findings align with the observations made by 22, who highlighted that the two most important factors in building maintenance are the skill of the maintenance crew and the labor shortage. They further emphasized that even with adequate funding for building maintenance, the expertise of the maintenance staff is crucial for successfully completing maintenance work. Some maintenance tasks require specialized workers, and without them, the work may not be carried out effectively.

Inadequate Budget

Participants 5, 7, and 18 raised the issue of budget as one of the barriers they experience. Participant 18 indicated that a shortage of budget affects the maintenance plan, leading to the postponement of some activities. According to 9, building owners should ensure sufficient funding for maintenance work in their annual budgets because it is a vital and necessary function. They further emphasized that without funding for the required maintenance tasks, the building will not be properly maintained.

Shortage of Material and Tools

Some participants highlighted the shortage of resources, including human resources, materials, and tools, as a setback in ensuring proper maintenance (P2, P11). Participant 2 mentioned, "We do not have materials, and the available material is for medical equipment and the chiller plant only. We do not have any materials used for other building maintenance." This finding is supported by 15, who noted that due to the small scale of maintenance operations, often carried out by an in-house team, tools and equipment are considered crucial for structural maintenance.

Delay in the Procurement Process

Participant 7 remarked that delays in processing requisitions by the procurement department occasionally force maintenance work to be put on hold. He also mentioned that documents are sometimes misplaced during the process, further contributing to delays. 23 supported this finding by noting that one issue impacting maintenance management is the difficulty in procuring spare parts due to a lack of funding. According to 24, procurement procedures and the prioritization of maintenance demands must be considered when developing criteria that influence maintenance practices. 25 found that public sector clients' performance during the procurement process is affected by significant obstacles and flaws, primarily due to a lack of qualified
supply chain personnel fulfilling their roles and responsibilities.

Lack of Transportation
Participants emphasized that the absence of vehicles or other means of transportation to travel to clinics or hospitals for maintenance work is a barrier to implementing maintenance strategies. They mentioned that work delays occur when there is no mode of transport available. 26 supported these findings by stating that transportation is a common problem and a barrier to accessing hospital services. 27 also supported this by stating that the timely delivery of construction materials depends on transport efficiency.

Poor Quality of Construction Materials
One participant noted that they often experience leaks in different areas despite fixing one area (P17). 28 supported this finding by stating that hospital structures may require significant maintenance costs, such as repairing damaged sections resulting from the use of substandard materials. Additionally, 29 supported this conclusion by adding that building components decay at different rates based on the quality of materials and the effectiveness of the construction process.

5.0 CONCLUSION AND RECOMMENDATIONS
The identified barriers during the study included a lack of manpower, elderly staff members, unskilled personnel, shortages of materials, tools, and finance; delays in the procurement process, lack of transportation, and poor-quality construction materials. The Limpopo Department of Health must prioritize reducing these identified hurdles, especially the shortage of employees allocated to perform maintenance at public healthcare facilities in the province of Limpopo. Additionally, materials, tools, and an appropriate budget should be made available to support maintenance tasks at each public healthcare facility. Addressing these issues should involve strict adherence to National Treasury policies that govern public sector operations.

Based on the findings, it is recommended that existing maintenance policies such as the Government Immovable Asset Management Act and the National Infrastructure Maintenance Strategy, be developed with input from bodies such as the Construction Industry Development Board and the Council for Scientific and Industrial Research, be utilized to assist the provincial government in formulating its own policies and standard operating procedures. Furthermore, providing training and development opportunities for the maintenance team in alignment with maintenance strategies can enhance their knowledge when selecting maintenance strategies.

Additionally, qualified maintenance officers should be appointed to execute maintenance strategies with a thorough understanding of the work. Finally, the government and various stakeholders responsible for healthcare facility upkeep should allocate an adequate budget to ensure proper maintenance of existing buildings. Measures should be taken to ensure that these funds are used for their intended purposes.

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The Potential of Circular Economy Practices in the Built Environment in Africa: A Perspective of Construction Industry Stakeholders

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ABSTRACT

Purpose of this paper
Circular economy (CE) practices are currently being explored across the world. However, it remains unknown whether these practices are applicable in different contextual settings. For that reason, this paper seeks to reveal the potential CE practices in the construction industry likely to drive the circularity transition in Africa.

Design/methodology/approach
The study adopted a quantitative approach, whereby a survey comprising of 33 CE practices representing the five lifecycle phases of a building were adopted. The respondents ranked these CE practices based on their likelihood of driving Africa built environment towards circularity.

Findings
The top ranked CE practices included minimising waste, adaptability, and flexibility of buildings. Interestingly, these practices represented the construction and operation/use phases of the building. Furthermore, it appears that the future use of a building is highly significant in circularity. On the other hand, the use of traditional building techniques (e.g., rammed earth), reverse logistics and design for disassembly or modularity were lowly ranked. Paradoxically, the use of traditional building methods although it is a common practice in Africa, yet the industry seems to not favour its CE potential.

Research limitations/implications
This pilot study potentially omitted some of the practices that are unavailable in literature and yet they are widely
practiced in Africa. For that reason, the study suggests that the future studies should expand their sources of CE practices through an exploratory study of both literature and industrial practices. Furthermore, for a wholistic view of the potential of CE practices, these should then be validated across Africa.

**What is original/value of paper.** The paper provides a ranking of CE practices that can potentially drive the transition of the African built environment towards a circular economy.

**Keywords:** Circular Economy, Built Environment, Africa, Construction Industry, Circular Practices
1.0 INTRODUCTION

The construction industry has, for a long time, been deemed a laggard when it comes to adopting novel or technological advancements. Most recently, the industry has gained attention because of its unsustainable consumption of raw materials ranging between 40-50% (Seyis, 2020), evidenced by the traction of policy makers, academics and industry collaboratively exploring sustainable ways of delivering construction projects. Such initiatives are anchored on the belief that without rethinking resource production and consumption, the construction industry is likely to plunge the globe into a catastrophic resource scarcity challenge (Heshmati, 2017). Consequently, resource scarcity will further drive the cost of both materials and buildings high which would have seismic effects on the viability of the building sector (Han et al., 2020; Fernholz et al., 2020). Therefore, bearing that in mind, the circular economy has been viewed as the solution to this impending challenge associated with the construction industry. A circular economy is defined as an approach focused on three fundamental principles, reduce, reuse and recycle (Ellen MacArthur Foundation, 2013; 2017). Heshmati (2017) notes that Reduce entails the reduction of dependence on virgin materials while Reuse explores the means through which the extracted materials can be used repeatedly without having to extract new materials (i.e., extending the lifespan of the current building stock). Ultimately, with reuse principles, the industry is likely to reduce the amount of virgin materials that are excavated for new construction projects. Lastly, Recycle is a means by which the industry alters the properties of the current materials to either produce secondary materials that are upcycled (value addition) or downcycled (value reduction) (Guerra et al., 2021). Although, the recycling agenda has been around for some time, Potting et al. (2016) and Cimen (2021) criticise recycling for its intense use of energy to alter the state of materials for repurposing. Evidently, the circular economy principles are aimed at achieving three fundamental goals, reduce waste and pollution, elongate material lifespan, and adopt regenerative systems (Ellen MacArthur Foundation, 2013). Furthermore, anchored on these objectives, the construction industry has devised an array of innovative circular practices that are likely to advance the circularity agenda although the full extent of their potential remains unknown as most of them are in their embryonic stages of adoption.

The Ellen MacArthur Foundation (EMF) has been a frontrunner in recommending circular practices that the construction industry can adopt worldwide (Ellen MacArthur Foundation, 2013). However, of late, there are various practices that have been put forward by several organisations that they consider to be instrumental in driving the circularity agenda (Alonso-Murioz et al., 2022; Condotta and Zatta, 2021). At a global scale, the World Green Building Council, African Circular Economy Network (ACEN), the European Union and other organisations have designed their own practices (Huovila & Iyer-Raniga, 2021; Gibberd, 2020). Notably, Nubholz et al. (2023) recently advocated for a need to move from just circular strategies to action within the building sector. Despite such advancements in the discourse, what appears to be the common understanding across different organisations is that the construction industry although it is fragmented nature, circular economy practices should be adopted across the lifecycle phases (Huovila & Iyer-Raniga, 2021). A typical construction project undergoes the following distinct phases; design, construction, operation, maintenance and end of life or demolition (Kibert, 2016). From a lifecycle perspective, it is arguably evident that each of these phases present different stakeholders who have a pivotal role to play in the circularity transition agenda (Leising et al., 2017). Furthermore, Gibberd (2020) contends that manufacturing of materials also is significant in understanding how the construction industry adopts circularity practices (Mirzaie et al., 2020). Some of the practices that are adopted in these include (1) Design: design for adaptability and flexibility, specify recycled materials, and design for disassembly, (2) Manufacturing: use less hazardous materials, use secondary materials, apply take-back schemes (3) Construction: minimise waste, locally procure materials, and procure reused materials (4) Operation and Maintenance: adaptability, low maintenance buildings and flexibility (5) End of Life: reuse of products, selective demolition, and track the disposal of deconstructed materials (Çetin, et al., 2021; Eberhardt et al., 2021; Iodice, et al., 2021; Gibberd, 2020; Antwi-Afari et al., 2021; Cottafava & Ritzen, 2021; Guerra et al., 2021; Benachio, et al., 2020; Dokter, et al., 2021). The are some of the dominant circular economy practices that are applied in the construction industry.

Although there are vast circular economy practices in the construction industry, what remains unknown
is which practices are best suited for which regions. This explains the rapid emergence of various circularity transition dashboards or instruments across the world as the industry grapples with the sustainability agenda within the built environment. Arguably, the circularity agenda and focus of the Global North might perhaps be significantly varied with that on the Global South. To that end, this paper explores some of the practices as suggested in literature and empirically tests their likelihood of being adopted by the construction industry in the African continent. The study was delimit to Africa as it served as pilot study for a PhD study that explored the enablers and drivers of the circular built environment in the African continent.

2.0 LITERATURE REVIEW

Operationalization of the sustainability concept has for a long time been perceived as a daunting exercise. Although, sustainability has been around for some time, how to accurately measure it has been marred with complications and inconclusion (Heshmati, 2017; Bassi et al., 2021). As a result, various industries have devised several tools, principles, practices and checklists as means through which the sustainability concept can be measured (Cambier, et al., 2020; Potting et al., 2016; Huovila and Iyer-Raniga, 2021). Lately, circular economy has become a buzzword across sectors as it seems to provide a more robust approach through which companies can possibly measure and assess their sustainability activities. As a consequence, the construction industry which has, for a long time, been deemed unsustainable has also seen an exponential increase in the ‘urgent need’ to adopt and deploy circularity practices (Antwi-Afari, et al., 2021; Mangialardo & Micelli, 2018). The circular economy practices are activities that the companies apply to achieve three fundamental objectives, reduce waste and pollution, elongate the use of current materials and use of regenerative systems through rethinking the design of products (EMF, 2013). Several scholars have explored the subject of CE practices that are available in the construction industry across the globe. Nonetheless, what appears to be common is that although there is a need for the transition towards circularity to achieve sustainability, these practices are seemingly inexhaustive and continuously evolving (Heshmati, 2017). That further suggests that prior to adopting the CE practices, the industry should validate these with their context so that they can apply practices that are relevant to their setting.

To understand the CE practices that can drive the sustainability agenda, it is imperative for one to appreciate the nature of the construction industry. The industry is mainly anchored on the production of a unique product which is called a building. Buildings are projects that are executed within a set timeframe (Guerra & Leite, 2021). These projects follow a predominantly systematic pattern which is initiated by the client who is the building owner. The client engages an architect who designs the project. At the design stage, the architect’s material requirements are largely informed by what is available in the market. Just like Gibberd (2020) argued that, for circularity to be attained, the manufacturing industry cannot be ignored as it outlines the type of materials from which the architect can choose from (Yu et al., 2021). After design stage, the contractor is engaged through a tendering process with the bidder who best meets the project specifications being awarded the project. In a traditional design-bid-build procurement model (which remains dominant to date) the contractor is responsible for converting the project design into a ‘live’ building structure as per the client’s specifications (Plusquellec, et al., 2017). Upon the successful completion of the building project, the contractor hands over the building and the owner assumes responsibility for the use or operation of the building. The use of the building leads to maintenance of the facility so that it remains habitable throughout its lifespan. At the end of the lifespan of the building, it is either repurposed or demolished. For the sustainability agenda to be attained, all the project lifecycle stages should embody the circular practices (Leising, et al., 2017; Braakman, et al., 2021).

Several scholars have proffered varying CE practices for adoption in the construction industry. Arguably, a majority of these scholars are of the view that lifecycle perspective of the projects provide a better premise through which one can view the circularity agenda promoting sustainability in the construction industry (Whyte et al., 2020; Benachio, et al., 2020; Dokter, et al., 2021). That being said, it appears that most scholars also consider practices as the most critical stage to initiate the circularity agenda (Dokter, et al., 2021). Undoubtedly, this is a noble standpoint as by and large contractors reproduce on site what will be detailed by the architect's
design. Any deviation from the project blueprint is largely frowned upon in the construction industry, which explains why the industry is largely regulated to closely monitor any possible variances from the initial design irrespective of its benefits (Mirzaei, et al., 2020). Some of the design CE practices include design for adaptability and flexibility, specify recycled materials, specify reclaimed materials, design out waste, design for standardization and design for disassembly (Adams, et al., 2017). Although specifying the need for use of recycled materials, the generic outlook is that recycled materials are viewed as less valued than the virgin materials (Potting, et al., 2016). Furthermore, it is argued that lack of standardization of reclaimed or recycled materials also heightens the lack of trust that the market has on adopting such materials (Zhang, et al., 2021). However, designing out waste seems to be gaining traction particularly when it is coupled with design for disassembly (EMF, 2017). Closely related to the design stage is the manufacturing phase. The production of materials determines the available stock of materials informing design choices. The CE drive with regards to manufacturing is exploring alternative materials that are less costly but with longer lifespan to remove a strain on extracting virgin raw materials. Some of the CE practices in manufacturing including increasing material lifespan, use of less hazardous materials, eco-design materials, using less materials, applying take-back initiatives and reverse logistics (Adams, et al., 2017; Gibberd, 2020; Zhang, et al., 2020). Notably, to increase material lifespan calls for implementing research and development which is a costly initiative. Furthermore, such a practice also catalyses the need for collaboration between industry and academic institutions. Evidently, CE practices involve a wide variety of stakeholders.

Most of the activities in a construction project take place on-site. Although most of the activities on construction projects are done on site, it should be noted that what is done on site is simply informed by the prior stages of the lifecycle (Huovila, et al., 2019). Nonetheless, this phase also includes some of the fundamental practices such as minimizing waste, procuring recycled or locally produced materials, reused materials, off-site construction, and use of traditional building techniques (i.e., rammed earth) (Adams, et al., 2017; Gibberd, 2020). Minimising waste is one of the main objectives that EMF (2013) advocates for in the circularity transition. In Africa, over 90% of the waste materials still finds its way to the landfills and most of the waste is attributed to the construction industry (United Nations Environment Programme, 2018). More so, it should be noted that despite the energy challenges associated with the recycling of materials, the use of recycled materials has faced another bottleneck. The main challenge with using or recycled materials is the quality aspects (Potting, et al., 2016). The construction industry is highly regulated to ensure that the end products (buildings) are of the approved quality (Iodice, et al., 2021). Failure to ascertain the quality standard of recycled materials affects the widespread use of these materials. Furthermore, off-site construction, although it is not a new phenomenon, is largely affected by the availability of workshops for off-site fabrication. That explains the reason for its limited application especially in emerging economies such as Africa (Dams, et al., 2021). For a long time, African countries have adopted the use of traditional building techniques particularly in the rural areas and in self-help dwellings in informal settlements (Loggia, et al., 2015). Despite embodying circularity properties, traditional building techniques such as rammed earth, appear to have been associated with poverty for a very long time. For that reason, it remains to be seen whether the circularity agenda will adopt these techniques in contemporary construction (Gibberd, 2020).

Within the CE agenda, the building use or operation is an essential phase. In other words, how a building is operated and maintained determines whether it continues to embrace the circularity principles (Wuyts, et al., 2019). Arguably, what makes this phase complex is that most of the time the buildings are operated by tenants who might not fully understand the circularity practices upon which the building was constructed on. Nonetheless, some of the CE practices in the operation phase include minimization of waste, adaptive use, flexibility, easy to repair and low maintenance buildings (Adams, et al., 2017). Dolla (2020) argues that for a long time, the maintenance of buildings is the least considered exercise in the building lifecycle. However, for circularity to be attained, that should not be the case. Lastly, it’s the end of life (EoL) of a building. Debatably, there are limited options on how to demolish the building at this stage because demolition or disassembling a building is informed by the design which is initiated at the design stage. Nonetheless, CE practices such reuse of products, dismantling and selective demolition can be applied at this stage (EMF, 2017; Adams, et al., 2017). With the
advent of big data technology, Murtagh et al., (2020) and Çetin et al., (2021) suggest that tracking of the disposed materials can potentially be employed at this stage as well.

Table 2.1. A summarised list of lifecycle CE practices in the construction industry.

<table>
<thead>
<tr>
<th>Lifecycle Phase</th>
<th>CE Practices</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Design for adaptability and flexibility</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Specify recycled materials</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Specify reclaimed materials</td>
<td>Adams et al., (2017)</td>
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<tr>
<td></td>
<td>Design out waste</td>
<td>EMF (2013; 2017)</td>
</tr>
<tr>
<td></td>
<td>Design for standardisation</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Design for disassembly</td>
<td>Condotta and Zatta, (2021)</td>
</tr>
<tr>
<td></td>
<td>Design for modularity</td>
<td>Mirzaie et al. (2020)</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Increase material lifespan</td>
<td>EMF (2013; 2017); Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Use less hazardous materials</td>
<td>Gibberd (2020)</td>
</tr>
<tr>
<td></td>
<td>Eco-design principles</td>
<td>Gibberd (2020)</td>
</tr>
<tr>
<td></td>
<td>Manufacture for product standardisation</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Use secondary materials</td>
<td>Potting et al. (2016)</td>
</tr>
<tr>
<td></td>
<td>Manufacture for product disassembly</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Use less materials</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Apply take-back schemes</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Reverse logistics</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td>Construction</td>
<td>Minimise waste</td>
<td>UNEP (2018); Adams et al., (2017)</td>
</tr>
<tr>
<td></td>
<td>Procure materials locally</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Procure reused materials</td>
<td>Adams et al. (2017)</td>
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<tr>
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<td>Off-site construction</td>
<td>Adams et al., (2017)</td>
</tr>
<tr>
<td></td>
<td>(2020) Use traditional building techniques</td>
<td>Murtagh et al., (2020)</td>
</tr>
<tr>
<td>Operation</td>
<td>Minimise waste</td>
<td>Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Adaptability</td>
<td>Poveda (2017); Adams et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>Poveda (2017); Adams et al.</td>
</tr>
<tr>
<td></td>
<td>Low maintenance buildings</td>
<td>Dolia (2020); Adams et al. (2017)</td>
</tr>
<tr>
<td>End of Life (EoL)</td>
<td>Reuse of products</td>
<td>Mirzaie et al. (2020)</td>
</tr>
</tbody>
</table>

Closed-loop recycling - recycled waste is processed and re-purposed to create new items. Open-loop recycling - recycling a product into a different product.
3.0 METHODOLOGY

The study adopted a quantitative research design. Fellows and Liu (2015) state that most of the construction industry research has been executed from a positivistic viewpoint which provides an objective perspective of the phenomena understudy. Therefore, informed by that standpoint, since the authors were desirous to rank the CE practices in order of their significance in transitioning the construction industry towards circularity in Africa a quantitative approach was considered more appropriate. As a result, a 5-point Likert scale was adopted in the survey, with the options Strongly Disagree, Disagree, Unsure, Agree, and Strongly Agree (Kyriazos & Stalikas, 2018). For this pilot study, a total sample of 100 was scientifically drawn from the African construction industry stakeholders and the CE experts. The sample represented the governments, academia, construction industry and non-governmental organisations. An online link was generated through Google Forms© and distributed via emails. To widen the sample reach, the authors also randomly shared the link to relevant groups and individuals via LinkedIn and Facebook. For the inclusion criteria, the authors ensured that those who had both knowledge and experience about the African construction industry participated through clearly enunciating that in the Request for Consent Pop-Up Page. The data was collected, cleaned, and coded using Excel 2016 before being exported to IBM SPSS for analysis.

4.0 RESULTS

4.1 Sample demographics information

A total sample of 82 respondents took part in the study. These respondents represented 14 African states namely: Ghana, The Gambia, Nigeria, Ivory Coast (Western Africa), Kenya, Tanzania (Eastern Africa), Botswana, South Africa, Namibia, Malawi, Zimbabwe, Zambia (Southern Africa), Morocco (North Africa), and Cameroon (Central Africa). In addition, approximately 4.9% of the respondents were resident in the United States of America, China, Switzerland, and The Netherlands. Different professions are pursuing CE, although it appears that Quantity Surveyors and Architects contributed a significant proportion of nearly 35.4% and 13.4% respectively. A total of 70% of the respondents represented researcher/academia, consultancy and contracting. It seems these are the main groups that are in the forefront of advancing circularity in Africa. The majority of the respondents had attained a Master’s degree (52.4%) and had work experience not exceeding five years. Cumulatively, approximately 84% of the respondents noted that they had an average to above average knowledge of CE practices in the construction industry while only 3.7% deemed themselves as experts. The low level of experts was expected considering that CE in Africa is relatively new. Nonetheless, an average understanding of the CE practices was considered important in this study so that the respondents could perhaps correctly rank these practices.

4.2 Reliability (Cronbach Alpha) Computations

To check the reliability of the five scales, the Cronbach alpha (α) was computed (Cronbach & Meehl, 1955). Table 4.1 shows the results of the reliability scores for the different lifecycle phase factors. Out of the five
factors, only the construction practice had a low \( \alpha \) equivalent to 0.776. Nonetheless, the score was not low enough to make the scale questionable. For that reason, the study did not modify any factors within the construction phase scale, so further analysis was done.

### Table 4.1. Reliability computations for the survey instrument.

<table>
<thead>
<tr>
<th>Lifecycle Phase</th>
<th>No. of items</th>
<th>Cronbach Alpha (( \alpha ))</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design practices</td>
<td>7</td>
<td>0.881</td>
<td>Good</td>
</tr>
<tr>
<td>Manufacturing practices</td>
<td>9</td>
<td>0.910</td>
<td>Excellent</td>
</tr>
<tr>
<td>Construction practices</td>
<td>6</td>
<td>0.776</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Operation practices</td>
<td>5</td>
<td>0.901</td>
<td>Excellent</td>
</tr>
<tr>
<td>End of life practices</td>
<td>6</td>
<td>0.931</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

**Note:** Cronbach’s alpha thresholds: \( \alpha \geq 0.9 \) (excellent); \( 0.9 > \alpha \geq 0.80 \) (good); \( 0.8 > \alpha \geq 0.7 \) (acceptable); \( 0.7 > \alpha \geq 0.6 \) (questionable); \( 0.6 > \alpha \geq 0.5 \) (poor); \( 0.5 > \alpha \) (unacceptable)

#### 4.3 Lifecycle CE practices ranking

A five-point Likert scale is an interval data scale. Therefore, the calculated mean score within the five-point scale is significant ranking the level of potential of each CE practice. The intervals for each scale are 0.80. The intervals scores for the different scales are as follows. **Strongly Disagree** the lower limit is 1.00 and the upper limit is 1.80, **Disagree** is from 1.81 to 2.60, **Unsure** is from 2.61 to 3.40, **Agree** is from 3.41 to 4.20 and lastly the **Strongly Agree** is from 4.21 to 5.00. The means of the individual statements in the project success parameter lie within the intervals which then explain the perceptions and attitudes of the professionals and contractors about the statement.

### Table 4.2. Design phase CE practices to promote circular transition in Africa.

<table>
<thead>
<tr>
<th>Design Practices</th>
<th>Mean Score (MS)</th>
<th>Standard Deviation (SD)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design for adaptability and flexibility</td>
<td>4.23</td>
<td>0.907</td>
<td>1</td>
</tr>
<tr>
<td>Specify recycled materials</td>
<td>4.13</td>
<td>1.120</td>
<td>2</td>
</tr>
<tr>
<td>Specify reclaimed materials</td>
<td>4.04</td>
<td>1.082</td>
<td>3</td>
</tr>
<tr>
<td>Design out waste</td>
<td>4.00</td>
<td>0.981</td>
<td>4</td>
</tr>
<tr>
<td>Design for standardisation</td>
<td>3.89</td>
<td>1.006</td>
<td>5</td>
</tr>
<tr>
<td>Design for disassembly</td>
<td>3.80</td>
<td>1.024</td>
<td>6</td>
</tr>
<tr>
<td>Design for modularity</td>
<td>3.80</td>
<td>0.909</td>
<td>6</td>
</tr>
</tbody>
</table>

### Table 4.3. Manufacturing phase CE practices to promote circular transition in Africa.

<table>
<thead>
<tr>
<th>Manufacturing Practices</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASOCSA 17th Built Environment Conference; 09 - 10 October 2023, CSIR International Convention Centre, Pretoria, South Africa</td>
<td>367</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 4.4. Construction phase CE practices to promote circular transition in Africa.

<table>
<thead>
<tr>
<th>Construction Practices</th>
<th>Mean Score (MS)</th>
<th>Standard Deviation (SD)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimise waste</td>
<td>4.39</td>
<td>1.003</td>
<td>1</td>
</tr>
<tr>
<td>Procure recycled materials</td>
<td>4.20</td>
<td>1.059</td>
<td>2</td>
</tr>
<tr>
<td>Procure materials locally</td>
<td>4.13</td>
<td>0.913</td>
<td>3</td>
</tr>
<tr>
<td>Procure reused materials</td>
<td>4.07</td>
<td>1.163</td>
<td>4</td>
</tr>
<tr>
<td>Off-site construction</td>
<td>3.85</td>
<td>1.112</td>
<td>5</td>
</tr>
<tr>
<td>Use traditional building techniques</td>
<td>3.28</td>
<td>1.220</td>
<td>6</td>
</tr>
</tbody>
</table>

### Table 4.5. Operation phase CE practices to promote circular transition in Africa.

<table>
<thead>
<tr>
<th>Operation Practices</th>
<th>Mean Score (MS)</th>
<th>Standard Deviation (SD)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimise waste</td>
<td>4.43</td>
<td>1.007</td>
<td>1</td>
</tr>
<tr>
<td>Adaptability</td>
<td>4.37</td>
<td>0.882</td>
<td>2</td>
</tr>
<tr>
<td>Flexibility</td>
<td>4.37</td>
<td>0.896</td>
<td>2</td>
</tr>
<tr>
<td>Easy repair and upgrade</td>
<td>4.26</td>
<td>0.953</td>
<td>4</td>
</tr>
<tr>
<td>Low maintenance buildings</td>
<td>4.18</td>
<td>1.032</td>
<td>5</td>
</tr>
</tbody>
</table>

### Table 4.6. End of Life (EoL) phase CE practices to promote circular transition in Africa.

<table>
<thead>
<tr>
<th>End of Life Practices</th>
<th>Mean Score (MS)</th>
<th>Standard Deviation (SD)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuse of products</td>
<td>4.34</td>
<td>1.009</td>
<td>1</td>
</tr>
<tr>
<td>Closed-loop recycling - process by which recycled waste</td>
<td>4.17</td>
<td>1.098</td>
<td>2</td>
</tr>
</tbody>
</table>
is processed and re-purposed to create new items
Open-loop recycling - means recycling a product into a different product 4.10 1.073 3
Selective demolition 4.06 0.973 4
Deconstruction/dismantle 4.05 1.088 5
Track the disposal of deconstructed materials 4.04 1.048 6

5.0 DISCUSSION
Tables 4.2, 4.3, 4.4, 4.5 and 4.6 illustrate the output of the mean score (MS) procedure. These MS range between 3.28 and 4.43. Put succinctly, the study findings strongly suggest that the respondents were mostly in agreement with the CE practices that were identified in literature as having a bearing on the CE transition in the construction industry in Africa.

5.1 Design Practices
Design is the anchor upon which the construction industry is hinged on. That further suggests that for the construction industry to transition towards circularity, design practices should not be underestimated (Dokter et al., 2021). The study reveals that of the available design principles that promote circular economy in the construction industry, design for adaptability and flexibility is ranked highest with a mean score of 4.23. Interestingly, although recycling or reclaimed materials have been perceived less appreciated (Potting et al., 2016) in most parts of the world because of the perceived limited quality standards, in Africa the designs which specify the use of recycled (MS = 4.13; SD = 1.120) and reclaimed materials (MS = 4.04; SD = 1.082) were ranked second and third respectively. The least ranked design practice was design for modularity (MS = 3.80; SD = 0.909). This is tandem with the findings of Adams et al., (2017) who noted some adoption challenges within the industry. Moreover, the African continent because it is still underdeveloped the use of modular construction remains low (Gibberd, 2020; Whyte et al., 2020). This is despite the potential that modularity has in advancing the circularity agenda. With modularity, the building can be dismantled a the end of life and the materials reused in other projects which reduces the use of virgin materials while elongating the useful life of the existing building stock (Mirzaie, et al., 2020). Closely related to the design for modularity is design for disassembly. Unsurprisingly, design for disassembly is also CE practices is also lowly ranked within the African continent.

5.2 Manufacturing Practices
Both Adam et al., (2017) and Gibberd (2020) are of the view that manufacturing is also a critical phase that drives circularity. For a long time, the manufacturing industry has been delineated from the construction industry irrespective of it supplying materials that determine the circularity of the industry (Heshmati, 2017). Therefore, with the advancement of circularity agenda, the manufacture of construction materials determines the extent to which the clients and architects contribute to circularity. The study revealed that the highest ranked practice is increasing material lifespan (MS = 4.34; SD = 0.984). The findings corroborate one of the three key principles of the EMF (2013; 2017), which enunciates that to reduce the dependence on raw materials, the construction industry should consider elongating the current building stock. The study also indicated that use of less hazardous materials (MS = 4.30; SD = 1.096) was secondly ranked by the respondents as having the potential of leading the construction industry towards circular economy. Furthermore, the manufacturing practices include the use of take-back schemes and reverse logistics (Adams et al., 2017). These are schemes whereby the product at the end of its usefulness it is returned to the manufacturer (Potting et al., 2016).
5.3 Construction Practices

For a long time, the construction activities have adopted the principles to minimise waste (Adams, et al., 2017). However, what has remained contentious is that during the construction project it is a little too late to change the material or techniques that the contractors use to construct a building as they abide to design specifications (Murtagh, et al., 2020). The study findings indicate that the contractors prioritise minimising waste across Africa (MS = 4.39; SD = 1.003). Such a standpoint is pivotal in promoting circular economy. Furthermore, although minimising waste is a good initiative, procuring recycled materials (MS = 4.20; SD = 1.059) and procuring materials locally (MS = 4.13; SD = 0.913) are CE practices highly instrumental in the circularity agenda (Condotta & Zatta, 2021). Arguably, recycled materials have attracted sharp criticism for energy that is used during the recycling process (Potting et al., 2016; Cimen 2021). On the other hand, purchasing materials locally reduce the carbon footprint related to transporting the materials. Unsurprisingly, the adoption of off-site construction was also lowly ranked. This is consistent with the findings that design for modularity and disassembly were also perceived to have a low potential in driving the circularity agenda in Africa. Although, the Global North has for a long time adopted the construction using modular panels (Adams et al., 2017), the study revealed that such technology in Africa remains low. Lastly, the use of traditional building techniques (MS = 3.28; SD = 1.220) such as rammed earth, dung, thatch, and associated materials remains negatively viewed across the continent (Gibberd, 2020). The findings show a conundrum that the African construction industry has particularly in the formal construction. Despite the prevalent use of these construction techniques or materials is widely adopted in the informal construction self-help buildings and in the rural areas, the techniques are yet to penetrate the formal construction industry (Loggia et al., 2015). Furthermore, one may argue that the benefits of such materials seem have not convinced the architects to design such buildings for the formal construction industry.

5.4 Operation Practices

The circular economy practices also inform the behaviour of the building owners or tenants during the operation of the building. Arguably, an eco-designed or circularity building if not operated like one, derails the attainment of the CE agenda in the construction industry (Adams et al., 2017). For that reason, this phase is of paramount importance although it has its own challenges as well. The respondents indicated that minimising waste by the building dwellers is the utmost priority (MS = 4.43; SD = 1.007). Additionally, it is also perceived that adaptability and flexibility of the building itself is essential in achieving a circular built environment (Adams et al., 2017). Considering that buildings are permanent structures which exist for an extended period of time, it is very significant that they are adaptable to future needs (Brundtland, 1987). Although, designing for the future is a mammoth task, having a building that is both adaptable and flexible for any conceived future use of the same space without demolition the building is important (Poveda, 2017). Adaptive reuse of the building is central to the circularity objectives of the construction industry. In tandem with the findings by Dolla (2020) that the maintenance of buildings is relatively neglected in most parts of the world, the respondents ranked the low maintenance buildings (MS = 4.18; SD = 1.032) as the least important CE practice. From the practices in this phase, it appears
that circularity calls for behavioural change in the way in which buildings are conceived, built, and operated.

5.5 End of Life Practices

The final stage in the lifecycle is the end of life (EoL). Usually, the EoL occurs after an excess of sixty years. For that reason, the future generations usually inherit the flaws of the designs of the previous generations. That entails that the current designers should have the future in mind (Brundtland, 1987). Only then shall the sustainability agenda which is promoted by circular economy practices be achieved. It appears that the reuse of products in the buildings has been deemed the most significant CE practice at this phase. Although, that is the case, the extent of reusable materials or products in the existing building stock remains unknown (Çetin, et al., 2021). Furthermore, respondents also indicated that both closed-loop (MS = 4.17; SD = 1.098) and open-loop recycling (MS = 4.10; SD = 1.073) are essential at this stage. Such a viewpoint corroborates the current perspective adopted by most professionals within the construction industry. Deconstruction of the buildings (MS = 4.05; SD = 1.088) is ranked 5th because of the construction industry is yet to adapt towards designing for deconstruction. Due to cyclical nurture of the building lifecycle it is evident that the EoL practices are largely informed by the design phase practices (Kibert, 2016; Nubholz et al., 2023). The CE transition is largely dependent on the availability of data. The data should contain the current building stock, the state of the materials and their composition. Such data is not readily available particularly in old buildings. To that end, the respondents ranked tracking the disposal of deconstructed materials (MS = 4.04; SD = 1.048) as the least potential driver towards circularity in Africa (Whyte et al., 2020). Nevertheless, although that is the case in Africa, it can be argued that the use of data to track materials is a potential gamechanger to driving the construction industry towards attaining CE.

6.0 CONCLUSION AND RECOMMENDATIONS

The study involved 82 professional experts who represented the entire regions of the continent of Africa. Based on that, the findings can be used as a litmus test of the stance of the continent of Africa with regards to the transition towards circularity in the construction industry. More so, the study also gives a picture of the current CE practices that are likely to promote the continent's objectives to move towards circularity. Consequently, the study also shows that although the CE practices are relatively a new phenomenon in the construction industry, most CE experts consent to their drive towards circularity transition. Such an agreement was evidenced by the mean scores of more than 3.00 across all the lifecycle phases. Therefore, it appears that such a finding contradicts the historically prevalent view that the construction industry lags in adopting the new technologies. The study indicates that the top three ranked CE practices in Africa are minimising waste (MS = 4.43 (operation phase); MS = 4.39 (construction phase), adaptability (MS = 4.37) and flexibility (MS = 4.37). These practices are within the construction and operation phases of the lifecycle of the building. Interestingly, this suggests that generally the construction industry considers more what happens on the construction site and the use of the building more than how it is designed.

On the other hand, the least three CE practices are use of traditional building techniques (MS = 3.28), reverse logistics (MS = 3.77) and design for disassembly (MS = 3.80) and modularity (MS = 3.80). The use of traditional building techniques although they are highly circular in nature, they are largely frowned upon because of their association with poverty. Africa seems to rank such a practice low regardless of its dominant use in the rural areas and informal settlements. Furthermore, the study concludes that design for disassembly and modularity remains low in the continent. The findings confirm that the continent still uses the traditional construction methods with the advent of disassembling members of the building not being currently embraced. It can be concluded that although design has a significant role in circularity, it appears that the respondents are
not in favour of new technologies such as modular construction perhaps because the continent is not adequately equipped for such techniques.

The main limitation of this study was that it did not cover all the 54 countries of the African continent to solicit the views of CE practices in those member states. Furthermore, the study also relied on the available literature to derive the CE practices which could potentially omit some of the practices that are not yet included in literature but are practiced. Based on these shortcomings of this pilot study, it is recommended that future studies should explore the same subject based on the CE practices that are both developed and practiced solely in Africa. For instance, an exploratory study that engages the various construction companies across the continent who are practicing circular construction could interview these companies and draw up a list of their CE practices. Thereafter, these contextual CE practices are then validated across the continent to ascertain their level of potential in promoting CE transition in the construction industry.

Funding:
This work is based on research supported in part by the National Research Foundation (NRF) of South Africa (Grant number 146382), by the SNSF/NRF Lead Agency Programme (Grant n.150547) and by the Royal Society Newton Advanced Fellowship (Grant no. NA150082). However, the results remain the sole responsibility of the authors and not the foundation.

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Available at:


Jacob Mhlanga, Theodore C. Haupt and Claudia Loggia

Adaptive Coping and Maladaptive Coping as Moderators Between Job Stressors and Subjective Wellbeing Among the Construction Workforce in South Africa

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ABSTRACT AND KEYWORDS

Purpose of this paper
This study investigated coping as a moderator between job stressors and subjective well-being among the workforce in the South African construction industry. The two types of coping investigated were maladaptive (negative) coping and adaptive (positive) coping.

Design/methodology/approach
To achieve the aim of the study, the direct relationships between the variables among the constructs of job stressors, subjective well-being, maladaptive coping, and adaptive coping were investigated. This quantitative research using survey questionnaires was conducted on a convenient sample of contractors (building and civil) in South Africa. Convenience sampling was used based on proximity and familiarity to the researcher and some data were obtained from referrals - a variant of snowball sampling. The population of the study comprised artisans/tradesmen, construction workers/labourers, and construction project professionals. After data were screened, a total of 201 questionnaires were suitable for further analysis. Further Exploratory Factor Analysis (EFA) was used to determine the sample adequacy for Structural Equation Modeling (SEM) and to determine factors of concern. Further analysis to test the hypothesised relationships was conducted using Confirmatory Factor Analysis (CFA), and SEM. Moderation was conducted in Process Macro v4.2 and subjective well-being was measured using the validated WHO-5 Wellbeing Index Measure.

Findings
The findings revealed that overall subjective well-being was good although not wholly satisfactory. Further, adaptive coping moderated the effects of job stress on well-being. While with maladaptive coping, moderation was significant for medium and low levels of consumption (substances), however, there was no significant
moderation effect at high levels of consumption which coincided with the negative significant relationship between wellbeing and maladaptive coping among these groups.

Practical implications
Further, the study is important in providing insights into how workers cope with stress in the industry, areas of concern in relation to their behaviour, and its consequences on the workers and the industry which may help in the implementation of safer construction practices.

Value of paper. This study addressed the knowledge gap in mental health studies in the South African construction industry.

Keywords: Stress, Coping, Wellbeing, Construction, Workforce, Moderation

1. Introduction
Job stress is increasingly becoming a critical public health concern which causes negative health effects (1). Although stress is not a disease, it is the body’s response to physiological or psychological demands exerted on it (2,3). Selye (3) defined stress as a “non-specific response of the body to any demands placed on it”. Stress describes the bodily processes created by conditions that exert physical or psychological demands on an individual (3). Job stress relates to the transaction between the worker and their work environment. It is a dangerous illness for industrialised economies which affects productivity and job satisfaction as it has negative effects on the physical and mental health of the workers (4,5,6,2). Stress may cause chronic and acute changes which can aggravate long-term damage to the body’s systems and organs, especially if the worker does not rest and recover (7). These changes subsequently result in a host of other common mental disorders, physiological ills and in some instances, suicide.

Job stress can be managed and treated like any other occupational health and safety risk if addressed at the organisational level, however, it is still treated as taboo and becomes an individual burden. The prevalence of job stress is known to have a high cost in terms of workers’ health, absenteeism, and low job performance (2). In construction, psychological stress stems from known and unknown demands such as unrealistic expectations, physically demanding work, poor working conditions, lack of communication, complicated interrelationships among different stakeholders, multiple stakeholders, lack of support, difficult tasks, deadlines and working overtime in some instances (8,9). The workforce in construction commutes long distances to work and some travel far away from their homes to work in foreign regions which could result in loneliness, a significant factor contributing to stress, depression and anxiety (10). These demands exerted on the body are also known as stressors (11).

Further, construction projects are seasonal which leads to job insecurities, and have strict deadlines with penalties for delays leading to constant working under tight deadlines - another significant stressor (9,12). Increased job demands and work pressure can lead to unintentional blindness as too much focus on complex tasks often leads to low levels of concentration (9). Over and above work pressure, workers must adhere to a plethora of safe working procedures as a result of the nature of the work and this can be extremely difficult.
when working under pressure. As a result, workers become increasingly worried about their well-being because exposure to work hazards may result in diseases or injuries. This incessant worry often causes chronic stress, depression, anxiety, boredom, frustration, and other negative emotions (12). Stress and unhealthy working conditions may also cause psychosomatic ills such as headaches, low energy, insomnia, back pain, or chest pain. It is evident that as mental and physical fatigue mount during prolonged work activities, workers are prone to unsafe behaviours (13).

In order to manage the physically and mentally demanding tasks, construction workers resort to either maladaptive (negative) or adaptive (positive) coping strategies. Coping is known to have a moderating effect on both stress and psychological well-being. It is closely related to the concept of cognitive appraisal and, refers to cognitive, emotional or behavioral efforts to address (master, reduce, or tolerate) a person-environment transaction (14,15). Adaptive coping operates as a mental health protective factor that effectively combats stress. These protective factors are linked to marital status (positive); high job control; high job support; low job demand; low workplace discrimination; family-friendly job opportunities; workplace justice; better welfare and positive socioeconomic measures. The protective factors make it easy for the construction workforce to positively manage stress both at work and outside work. Contrarily, some workers choose maladaptive coping which is linked to reduced work support and reduced job control. Maladaptive coping strategies include consumption of alcohol, drug abuse, avoidance behaviour and substance abuse (ADSA) (9). Construction workers are prone to maladaptive coping strategies because of their job characteristics which do not encourage openness about mental health issues as a result of the macho culture, physically demanding tasks and long working hours making it hard for active coping strategies. Further, the high illiteracy rate especially among blue-collar workers, is linked to unhealthy lifestyle habits.

While the nature of the industry significantly causes stress, it also affects the workers’ overall mental well-being. Workers employ different coping strategies to achieve homeostasis. Coping plays a significant role in determining the workers’ psychological well-being. This paper investigates the moderating effects of coping on occupational stress and psychological well-being among the construction workforce. Job stress results in poor psychological well-being, construction accidents and the loss of human resources. The lack of development in this area of knowledge in the South African construction industry exacerbates the problem. Most stress and mental health studies in construction have been conducted in developed countries, like the UK, USA, New Zealand and Australia, while those conducted in South Africa are minimal and mostly focus on construction professionals. For example, previous studies on stress and mental health in South Africa have focused on comparing the perceived relationship between job stress and job demand, control and support (JDC/S) issues among CPPs; comparing the relationship between job stress and harassment and discrimination among CPPs as well as examining the effects of stress, stress and coping mechanisms and predictive modeling of stress as a function of JDC/S factors among CPPs (16,17,18,19,20,21,22,23). Furthermore, Haydam and Smallwood (24) conducted a study to identify the prevalence and causes of stress among civil engineers. Further, there is a general problem with using approaches from developed countries to address psychological issues in developing countries like South Africa. South Africa consists of a different demographic population mainly consisting of people of different ethnicities with different cultures, beliefs, values and lower levels of education. Given the diversity of the population, it is without a doubt that even coping strategies and their outcomes will be different. It is hoped that the focus on specific cross-cultural studies investigating the dearth of coping mechanisms and their prevalence
will assist in the development of effective stress management tools and contribute to the understanding of how workers appraise occupational stress.

2. Methodology

This quantitative, cross-sectional study, was conducted on a conveniently sampled population of contractors across South Africa. Data were collected from the construction workforce mainly artisans, construction labourers and construction project professionals (CPPs). To collect the quantitative data, questionnaires with close-ended questions were the preferred data collection method because they are inexpensive, because of the sensitive nature of the study and also to enable large amounts of data collection in the format appropriate for the chosen data analysis approach. The questions were kept as short as possible with clear instructions. Prior to the data collection, a snap survey was conducted on a conveniently sampled population to identify possible challenges and the challenges were overcome by restructuring some of the questions. Convenience sampling was favoured based on the proximity and familiarity of the sample population with the researcher. This sampling method maximised the responses because the study was conducted within a limited period. Further, some respondents were recommended by other participants – a variant of snowballing sampling technique. After receiving the questionnaires, data were screened for missing data, disengaged responses, extreme values and outliers to improve the quality of the data and a total of 201 questionnaires were suitable for further analysis. The questionnaire included the constructs coping, both adaptive and maladaptive, occupational/job stress (OccS), and the WHO-5 Wellbeing Index Measure. The questionnaire on adaptive coping was based on a 5-point Likert scale where the respondents were asked about their level of agreement with spending time with family, friends, sleeping, exercising, religion/spirituality and taking walks when feeling stressed. Questions for maladaptive coping were also based on a 5-point Likert scale and respondents were asked about their level of agreement based on the use of alcohol, cigarette smoking and cannabis smoking. Occupational stress questionnaires were also based on the Job-Demand/Support theory and integrated stress theories and measured stressors from the workplace such as organisational stressors and how they affected workers’ mental health with stress being a precursor for other mental conditions such as anxiety, depression, burnout, PTSD and suicidality. The WHO-5 measure for wellness was used because it is easy to interpret and understand and because it is a validated measure used across all disciplines to measure the subjective well-being of the general population. This validated measure was preferred due to its general applicability and ease of understanding.

Other questionnaires were designed by the author and Exploratory Factor Analysis (EFA) was conducted to assess whether the questions measured what the researcher intended to measure. Own questionnaires were developed from existing literature and psychological stress theories. The use of validated instruments may not necessarily apply in cross-cultural studies especially for coping and occupational stress due to diverse cultural practices and the perceptions around mental problems. After EFA was conducted, Confirmatory Factor Analysis and Structural Equation Modeling were employed to test the hypothesised relationships. IBM Statistical Package for Social Sciences (SPSS) v28 was used for descriptive statistics and Exploratory Factor Analysis (EFA), and IBM Amos v28 for CFA and SEM. Process Macro v4.2 was also used to test the moderation relationships. Further, composite reliability, Average Variance Explained and Cronbach’s Alpha were used to determine the reliability and validity of the constructs. This study received ethical clearance.
from the General Human Research Ethics Committee (GHREC) (Ethical Clearance Number: UFS-HSD2021/2006/22) at the University of the Free State. Informed consent was granted from the respondents before conducting the study and all research protocols were followed according to the requirements of the GHREC.

3. Results

The analysis of the data collected and the findings are presented in this section. Data were analysed using IBM Statistical Package for Social Sciences (SPSS) version 28. Tables were used to present data and key findings.

3.1 Respondents

The respondents of the study were the construction workforce working for contraction companies across South Africa. The sample consisted of construction workers/labourers, artisans and construction project professionals (CPP). Table 1 presents the profile of the respondents of the study.

<table>
<thead>
<tr>
<th>Table 1 Respondents Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>Age</strong></td>
</tr>
<tr>
<td>18 to 24</td>
</tr>
<tr>
<td>25 to 34</td>
</tr>
<tr>
<td>35 to 44</td>
</tr>
<tr>
<td>45 to 54</td>
</tr>
<tr>
<td>55 to 64</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>Education Level</strong></td>
</tr>
</tbody>
</table>

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The findings from Table 1 revealed there were more male respondents (81.6%) than female respondents (18.4%). The results differ from those of the usual gender distribution of the construction workforce in South Africa which usually has fewer than 12% female workers. Most respondents were between the age groups 25 to 34 years (43.3%) followed by the age groups 35 to 44 years (32.3%); 45 to 54 years (11.9%); 18 to 24 years (8.0%); and 55 to 64 years (4.5%) respectively. The average age of construction workers is 42.5.
However, the study findings suggested that most respondents were between the ages of 25 and 34 years. This may be attributed to the effects of Covid-19 as employment trends resulted in the youth experiencing the highest employment between February 2020 and March 2021 (32.5% to 35%), while older workers experienced a decrease from 45% to 41%. Therefore, the findings represent the current employment-to-population ratios in the industry. Construction workers (labourers) and artisans make up about 55% to 70% of its workforce, while construction professionals are between 30% to 45%. When categorising the working groups into CPPs, and artisans/labourers, the percentage distribution is 29%:71%. Therefore, the sample represents the population of interest adequately.

3.2 Exploratory Factor Analysis

The questionnaires for occupational stress and coping were developed by the researcher based on literature and the psychological stress model. In order to test for construct validity and to determine the number of factors necessary to explain the interrelationships among the set of variables measuring the constructs of job stress (OssS) and coping, exploratory factor analysis (EFA) was used. Therefore, EFA assisted in the identification of variables deemed suitable for measuring the factors of concern.

3.3 Data Inspection for Job Stress and Coping

Data inspection techniques were conducted to determine the sample adequacy required for EFA. The Kaiser-Meyer-Olkin test and Bartlett’s Test for sphericity were used to test for sample adequacy. Based on the results in Table 2 and Table 3 the sample met the size and variance requirements for conducting EFA based on the recommended thresholds for KMO (above 0.60) and Bartlett’s Test for Sphericity (p<0.05) (Hair et al., 2017).

<table>
<thead>
<tr>
<th>Table 2: KMO and Bartlett’s Test CMDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin Measure of Sampling Adequacy.</td>
</tr>
<tr>
<td>Bartlett’s Test of Sphericity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3: KMO and Bartlett’s Test Coping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaiser-Meyer-Olkin Measure of Sampling Adequacy.</td>
</tr>
</tbody>
</table>
Bartlett’s Test of Sphericity

<table>
<thead>
<tr>
<th>Bartlett's Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. Chi-Square</td>
</tr>
<tr>
<td>df</td>
</tr>
<tr>
<td>Sig.</td>
</tr>
</tbody>
</table>

### 3.4 Factor Extraction and Rotation

Principal Component Analysis (PCA) was the preferred factor extraction method because there was no underlying theory about the factor structure available precluding factor analysis (FA) for the current study. Therefore, no prior assessment of the factor structure of the primary data existed. Only one solution was extracted for each of the constructs job stress, maladaptive coping and adaptive coping. There was no need for factor rotation for this construction. The solutions were, therefore, considered unidimensional and adequate evidence of convergent and discriminant validity was provided for the constructs.

For job stress, the correlation values of 6 components (depression, anxiety, stress, post-traumatic stress disorder and burnout) were above the recommended cut-off value of 0.30 and < 0.90. For coping, the correlation values for the 6 components (sport/exercising, spending time with friends, talking to someone, hobbies, sleeping and relaxing and walking in nature) measuring adaptive coping and the 3 components (alcohol consumption, cigarette smoking, cannabis smoking) for maladaptive coping were above the recommended cut-off value of 0.30 and less than 0.90. The other components were dropped, and the retained components were deemed the most suitable for testing the hypothesised relationships.

### 3.5 The WHO-5 Wellbeing Index

The WHO-5 was used to measure the subjective well-being of the individuals. It is a validated well-being measure and there was no need to conduct EFA. However, CFA and reliability for the instrument were conducted along with the other three constructs of the study. Table 4 presents the descriptive statistics for the overall score. The WHO-5 measures well-being by calculating the raw score which is calculated by totaling the numerical values of the five answers - in this case the five means - where the raw scores range from 0 to 25, 0 representing the worst possible and 25 representing the optimum quality of life. The raw score is multiplied by 4 to obtain a percentage score ranging from 0 to 100 whereby, 0 represents the worst possible, whereas a score of 100 represents the optimum quality of life.

<table>
<thead>
<tr>
<th>Table 4: WHO-5 Wellbeing Index Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>----</td>
</tr>
</tbody>
</table>

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I have felt cheerful and in good spirits 201 4,04 1,296
My daily life has been filled with things that interest me 201 3,95 1,379
I woke up feeling fresh and rested 201 3,87 1,412
I have felt calm and relaxed 201 3,85 1,244
I have felt active and vigorous 201 3,77 1,341

From Table 4, the total score was determined by adding 4.04 + 3.95 + 3.87 + 3.85 + 3.77 which equated to 19.48. Furthermore, 19.48 x 4 = 77.92. Therefore, the WHO-5 score = 77.92. The score is above the cut-off score which is determined as ≤50. Scores < 50 are indicative of poor wellbeing. Therefore, it may be inferred that the workers had an overall good wellbeing, although not optimum wellbeing.

3.6 Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) was done in AMOS v28. The model was assessed for convergent validity and discriminant validity. Assessing reliability and validity was done as a further check on how well the measurement items fit the theory *a priori*. The reliability and validity statistics are based on the factor loadings from the CFA and are shown in Table 5.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Item Correlation</th>
<th>Factor Loading</th>
<th>C AVE R</th>
<th>Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational/Job Stress (OssS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Depression</td>
<td>0.683</td>
<td>0.756</td>
<td>0</td>
<td>0.446</td>
</tr>
<tr>
<td>2 Stress</td>
<td>0.528</td>
<td>0.628</td>
<td>0</td>
<td>0.446</td>
</tr>
<tr>
<td>3 Anxiety</td>
<td>0.653</td>
<td>0.735</td>
<td>0.82</td>
<td>0.827</td>
</tr>
<tr>
<td>4 PTSD</td>
<td>0.588</td>
<td>0.644</td>
<td>0.82</td>
<td>0.827</td>
</tr>
<tr>
<td>5 Burnout</td>
<td>0.621</td>
<td>0.677</td>
<td>0.82</td>
<td>0.827</td>
</tr>
<tr>
<td>6 Suicidality</td>
<td>0.488</td>
<td>0.546</td>
<td>0.82</td>
<td>0.827</td>
</tr>
</tbody>
</table>

Maladaptive Coping
From Table 5, the standardised factor loading of all items were > 0.40 which is the minimum recommended for a sample size of 200 (Hair et al., 2017). The recommended threshold values for the parameters are AVE ≥ 0.5. However, AVE = 0.40 can be accepted if the CR > 0.60 for the construct (Hair et al., 2019). The recommended threshold for CR between 0.60 and 0.70 is appropriate (ibid). Although 0.60 is sometimes used as a lower cut-off value, 0.50 is considered acceptable (ibid). The Cronbach alpha and composite reliability for all variables are > 0.70 so it shows that the variables had good reliability.
3.7 Testing the hypothesised relationships: Structural Equation Modeling

In order to test the hypothesised relationships adaptive coping (ADC) and maladaptive coping (MLDP) moderated the relationship between Occupational Stress (OccS) and well-being (WB), structural equation modeling was used to test the relationships between the constructs indicated in Figure 2. However, before conducting the moderation relationships, direct relationships were tested.
Based on the hypothesised relationships, there was no significant relationship between occupational stress and adaptive coping ($\beta=0.083$, $P=0.502$). The hypothesised relationship between occupational stress and maladaptive coping was supported ($\beta=0.341$, $P<0.000$). Further, maladaptive coping was significantly and positively associated with adaptive coping ($\beta=0.190$, $P<0.047$). Also, the hypothesized relationship between occupational stress and well-being was negatively significant ($\beta=-0.411$, $P<0.000$).
However, maladaptive coping and well-being were not significantly associated ($\beta=-0.019$, $P<0.767$). Finally, adaptive coping was significantly associated with well-being. Based on these findings, the hypothesized relationships for H2, H3, H4 and H6 were supported. However, H1 and H5 were rejected since the p-value is not significant and did not support the hypothesised relationships.

### 3.8 Moderation Test

Moderation analysis was conducted by treating occupational stress as an independent variable and well-being as a dependent variable. Adaptive coping and maladaptive coping were treated as moderating variables. Moderation analysis was performed in Process Macro v4.2 using model 1 for each moderation relationship. The results are provided in Table 8.

<table>
<thead>
<tr>
<th>H. No.</th>
<th>Path</th>
<th>Estimate</th>
<th>S. E.</th>
<th>T</th>
<th>P</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>H7</td>
<td>OccS*AD C&gt;WB</td>
<td>0.22</td>
<td>0.0</td>
<td>2.01</td>
<td>0.015</td>
<td>Supported</td>
</tr>
<tr>
<td>H8</td>
<td>OccS*ML DC&gt;WB</td>
<td>0.13</td>
<td>0.0</td>
<td>1.05</td>
<td>0.05</td>
<td>H8 Not Supported (High MLDC is not a significant path)</td>
</tr>
</tbody>
</table>
The results in Table 8 indicate that the relationship between OccS and WB was moderated by ADC (β=0.222, P<0.05) and therefore, H7 was supported. Additionally, the slope analysis in Figure 3 was analysed to further explain the interaction. The slope diagram explains low (2.50) to medium (3.00) to high (4.00).
adaptive coping practices. Individuals with low adaptive coping practices were more susceptible to decreased well-being when faced with occupational stress the individuals who had employed higher adaptive coping strategies. On the contrary, MLDC did not moderate the relationship between OccS and WB ($\beta=0.133$, $P>0.05$). Based on the result, low (1.00) and medium (2.00) had a significant relationship except for high MLDC practices. Therefore, based on the path diagram in Figure 4, maladaptive coping affected individuals with higher well-being more than individuals with moderate well-being who highly adopted MLDC when faced with OccS.

4. Discussion and Conclusion

To further understand the relationships between occupational stress and well-being, coping was introduced as a moderator. The hypothesised relationships were (H7) adaptive coping moderates the effects of occupational stress on wellbeing. The second moderation relationship was hypothesised as (H8) maladaptive coping moderates the effects of occupational stress on wellbeing. For H7, adaptive coping buffered the effects of occupational stress on well-being based on the positive and significant relationship. This is in line with several literature findings and with the psychological stress theory. Adaptive coping operates as a mental health protective factor that effectively combats stress (15). Coping processes may try to alter the person–environment realities behind stress or they could also relate to internal elements and try to change the appraisal of the demanding event (14). Contrarily, for H8, there was no significant relationship between maladaptive coping as a moderator for occupational stress and well-being. Both OccS and MLDC affected wellbeing negatively and the lack of significance could be attributed to the negative effects. However, it is difficult to know and assess how different degrees of stress compared to MLDC affect wellbeing although the findings did reveal that the moderation is significant at low to medium levels of MLDC use/practices.

This study investigated the direct relationships between coping, occupational stress and wellbeing; and, the moderating effects of coping on occupational stress and wellbeing. For adaptive coping, the study only focused on active coping, avoidance coping, social support and spiritual coping. Further research could focus on the combination of emotional-focused coping and problem-focused coping strategies. The current study also focused on well-being in relation to subjective well-being by administering the WHO-5 Wellbeing Index. This focuses more on the wellness aspect. Future studies could also focus on a holistic overview to assess eudaemonic and hedonic well-being and use a mixed-method approach to gain an in-depth understanding of the workers’ mental health. It is also recommended that a country-specific scale should be used due to cross-cultural differences. There are several limitations to the study attributed to the sampling method used. These may be associated with the type of study design which employed survey self-report questionnaires such as response bias, social desirability, introspective ability, understanding and limitations with rating scales may affect.

Key findings revealed surprisingly that, maladaptive coping did not buffer the effects between occupational stress and well-being. This is interesting and calls for further investigation. Another issue is the insignificant relationship between maladaptive coping and well-being. Although it is widely accepted that maladaptive coping affects well-being, this was not the case for the current study. It is imperative to investigate the perceptions of the workers towards substances since the study only focused on subjective well-being in relation to the WHO-5 Wellbeing Index. While designing better workplaces in construction is desirable, it may not be an immediate intervention to solving the industry’s problems. However, to sustain a healthy workforce,
educating them on how to better protect their mental health through effective coping strategies is important. This study is important as it addresses areas of concern regarding different coping strategies employed by the construction workforce and how these affect workers’ well-being in order to design healthy workplaces. Therefore, possessing this knowledge will help inform interventions, efficient coping strategies and better-informed mental health diagnostics.

Acknowledgments

The authors acknowledge the support of the National Research Foundation (NRF).

References


