EFFECTIVE FRAMEWORK TO REDUCE CONSTRUCTION WASTE IN SOUTH AFRICA

By

Nontlahla Mphako (219116679)

Thesis submitted in fulfilment of the requirements for the award of the degree of Master of Construction

at the

Department of Construction Management and Quantity Surveying, Faculty of Engineering and the Built Environment, Cape Peninsula University of Technology, Bellville, South Africa

Supervisor: Mr. Athenkosi Sogaxa

Co-Supervisor: Dr. Lance Wentzel

Bellville

December 2024

DECLARATION

I, Nontlahla Mphako, student number: 219116679, declare that the thesis entitled: "Effective framework to reduce construction waste in South Africa" is my original work and has not been submitted in any form for any other degree or qualification in any other university other than Cape Peninsula University of Technology. All sources of information and data used in this thesis have been properly acknowledged. It is submitted in fulfilment of the requirement for the degree Master of Construction at the Cape Peninsula University of Technology.

Signed:

Date: December 2024

ABSTRACT

Construction waste is a major environmental and financial problem that raises project costs and depletes resources in South Africa. The aim of this study is to develop a waste management framework to aid the reduction of construction waste in the South African Construction Industry (SACI). This study assesses the perceptions of contractors regarding construction waste management in construction sites, the key drivers for contractors' waste management practices in construction sites, the difficulties contractors face in cutting down on construction waste, the different approaches they take to accomplish this goal. A quantitative approach was used in this study. The construction companies operating in the Eastern Cape province of South Africa were the focus of this investigation. The data of this study were analysed using descriptive, inferential, and non-parametric statistics, using Statistical Package for the Social Sciences (SPSS) software version 29. Furthermore, the reliability of the research survey instrument was tested using Cronbach's alpha coefficient reliability while analysis of variance (ANOVA) was conducted to test the significant difference between the various cidb Grades 5–9 of contractors with reference to the cost concern to ascertain whether contractors had a consensus on their perceptions regarding construction waste management.

According to the findings of the study on contractors' perceptions of construction waste management, there are still worries about high disposal costs and a concentration on short-term advantages even if successful solutions can result in large long-term financial savings. The investigation demonstrates how supervisors' ineffective communication, reluctance to adopt new methods, and uneven application of policies have a detrimental effect on management attitudes. Inadequate training also results in a lack of knowledge about waste management regulations, safety, and the possibility of recycling or reusing products. The significance of managing compliance concerns and the impact of project requirements on contractors' opinions are further emphasized via factor analysis.

The results of the analysis of the main factors influencing contractors' waste management methods show that social, economic, and environmental factors interact intimately and were ordered according to each Relative Importance Index (RII). The necessity for sustainable practices that reduce environmental impact is highlighted by significant environmental factors such as recycling, waste reduction, water conservation, and resource efficiency. Cost-effective and regulated elements are the industry's focus, as seen by economic factors such recycling opportunities, material costs, and regulatory compliance costs. Best practices and community involvement are highlighted by social factors such as public awareness, industry standards compliance, and continuous education.

The finding from the study reveals that a major obstacle to contractors cutting down on construction waste is the absence of waste reduction plans, which are crucial for directing recycling, appropriate disposal procedures, and waste minimization. The factors that contributed to these challenges were found to be seven in number: poor communication about waste reduction, restricted access to recycling facilities, inappropriate material reuse on-site, absence of a zero-waste culture, difficulties finding nearby recycling facilities, insufficient waste management equipment, and challenges tracking waste generated on-site.

The study highlights that effective construction waste management in South Africa can be achieved through sustainable material selection, efficient procurement, proper handling, operational planning, and fostering a waste-conscious culture. Key strategies include adherence to regulations, training, collaboration with suppliers, and implementing 3R principles (reduce, reuse, recycle). Clear communication, scheduling, and strict policies further enhance waste reduction efforts. These practices collectively optimise resource use and minimise environmental impacts.

Keywords: Construction waste, Sustainability, Sustainable development, Waste management, Construction industry.

DEDICATION

I dedicate this thesis to my family, who have always been there for me: To my cherished mother, Mrs. G. Mphako, who has been my strength and light throughout this journey; to my late father, Mr. M. Mphako, whose memory and wisdom continue to inspire me every day; as well as to my two amazing sisters, Miss. N. Mphako and Miss. N. Mphako, who have served as my pillars of support. I will always be grateful for your support and belief in me, and this accomplishment is as much yours as it is mine.

ACKNOWLEDGEMENTS

I would like to thank God Almighty for giving me strength to continue to pursue my Master‘s degree and for giving me strength to be able to wake up each day to do my research. I would like to thank my supervisor and co-supervisor, Mr Athenkosi Sogaxa and Dr Lance Wentzel, for their support, academic guidance, motivation, and the extra mile in their supervision to ensure that we produce this product. I also appreciate the support from the Head of the Department of Construction Management and Quantity Surveying, Mrs Toni Stringer. I appreciate the Cape Peninsula University of Technology for providing the resources and facilities necessary for this research. Lastly, I extend my gratitude to all those whose work and contributions have been referenced in this thesis. This thesis would not have been possible without the collective support and encouragement of these individuals and institutions.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CIDB - Construction Industry Development Board

CW - Construction waste

DEA - Department of Environmental Affairs

GB - General Building

GDP - Gross Domestic Product

SACI - South African Construction Industry

GLOSSARY TERMS

Construction industry - The construction industry is large and involves several tasks, such as building, maintaining, renovating, or replacing fixed assets of different sizes (Greenhalgh & Squires, 2011).

Construction waste – Construction waste is any kind of debris from the construction process; it is formed mainly by materials such as concrete, wood, glass, sand, bricks and other construction elements (Rabea, 2016).

Contractor – Contractor is defined as a person who contracts to build, alter, repair, add to, improve, or demolish any building, highway, road, railroad, or other structure, project, development, or improvement to real property (Mathenjwa, 2020).

Drivers – Drivers are things that enable other things to advance, develop, or become more powerful (Hakanen & Rajala, 2018).

Material – Materials used in construction are known as building materials; buildings have been made using a variety of naturally occurring materials, including clay, pebbles, sand, wood, and even twigs and leaves (Gupta *et al*., 2015).

Reuse - Reuse is the action of using an item again, whether for the original function it was intended for or for another one (Bansal, Mishra & Bishnoi, 2016).

Site waste management – Site waste management is the reduction and minimisation of construction waste using waste management practices; it includes the use of recycled materials, the reuse of existing ones, and the decrease of procurement using accurate material estimations (Ali *et al*., 2019).

Waste – Waste is anything that is unnecessary, disregarded, left behind, rejected, or undesirable (Nyika *et al*., 2019)

Waste management - waste management is the collection, transportation, treatment, recycling or disposal and control of waste materials (Pereira *et al.,* 2023).

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Due to the impact on the environment and the scarcity of natural resources, waste management is a major worldwide concern (Ferronato & Torretta, 2019). Globally, nations that prioritize waste reduction, reuse, and recycling, including the Netherlands, Japan, and Germany, have implemented sustainable waste management methods (Kabirifar *et al.,* 2020). These actions have been successful in reducing environmental harm while promoting social and economic advancement (Das *et al.,* 2019). But in South Africa, where difficulties still exist in successfully putting similar tactics into practice, these developments are not reflected. This shows that there is a significant lack of adaptation and contextualization of global best practices in the South African construction industry.

The SACI significantly contributes to the economy, creating jobs and adding to the nation's Gross Domestic Product (GDP) (Saah, 2021). However, it is also a substantial source of environmental degradation due to construction waste generation (Purchase *et al.,* 2021). Estimates suggest that globally, construction accounts for 30-40% of total waste generation (Aboginije *et al.,* 2020). SACI mirrors this trend, producing large quantities of waste, including materials like concrete and bricks, which are predominantly disposed of in landfills (Islam *et al.,* 2019). This improper disposal exacerbates environmental challenges, including soil and water pollution and health risks (Siddiqua *et al.,* 2022).

The National Environmental Management: Waste Act of 2008 addresses these issues by requiring waste manufacturers to employ environmentally friendly waste management practices. However, there have been numerous challenges to its implementation. Due primarily to a lack of oversight and accountability, enforcement measures are frequently ineffective and stakeholder compliance levels vary (Li *et al*., 2019). Insufficient integration of sustainability principles into the construction industry and unclear waste reduction goals exacerbate these issues (Osmani *et al*., 2008). Other shortcomings in South Africa's construction waste management system include a lack of thorough waste audits to determine the types and amounts of waste, poor recycling infrastructure, and a lack of knowledge and training among contractors. According to Darko *et al.* (2017), growth is also impeded by operational and cultural constraints, such as a reluctance to embrace sustainable practices and a preference for immediate financial gain over long-term environmental protection. Informed policy creation and decision-making are further hampered by a lack of data on waste generation and disposal trends.

Although some construction firms have tried to implement waste management procedures, their efficacy has been constrained by the absence of a unified, sector-wide strategy. A lack of incentives for implementing sustainable practices, poor stakeholder communication, and insufficient mechanisms for waste tracking and reporting are some of the main obstacles. These shortcomings draw attention to the necessity of a customized, situation-specific framework that considers the difficulties faced by SACI. This study seeks to propose a framework that will provide strategies for waste reduction, reuse, and recycling, and recommendations for policy makers and other stakeholders in the industry. To encourage sustainable growth and ensure that the construction industry functions in an eco-friendly and sustainable way, South Africa needs an effective framework to reduce construction waste (Darko *et al*., 2017).

1.2 Problem statement

South Africa's construction sector is a key contributor to the national economy, but it also produces a lot of waste, which poses serious environmental and economic difficulties (Park & Tucker, 2017; Islam *et al*., 2019). In addition, construction waste which includes materials like concrete, wood, metals, and plastics, frequently ends up in landfills, contributing to environmental deterioration and resource scarcity (Akhtar & Sarmah, 2018). Sormunen and Kärki (2019) and Jethy *et al*. (2022) reveal that the current waste management techniques in the South African construction industry are inefficient and unsustainable, resulting in higher costs and environmental damage. Despite current regulations and waste-reduction initiatives, the industry continues to struggle with their successful implementation of construction waste reduction (Abarca-Guerrero *et al*., 2017). Ma *et al*. (2020) and Meng *et al*. (2021) highlight that lack of awareness, inadequate training, insufficient incentives, and scattered waste management systems impede growth. Furthermore, the range of construction project scales, from small residential buildings to massive infrastructure projects, hampers the implementation of a standardised waste reduction plan (Gangolells *et al*., 2014). Therefore, there is a need for an effective framework to reduce construction waste in South Africa and enable the construction industry to operate sustainably, reduce its negative impact on the environment, and promote sustainable development.

1.2.1 Sub-problems

Contractors are often confronted with inadequate construction waste management and sudden unable-to-reduce construction waste.

- The various perceptions of contractors regarding construction waste management practices at construction sites.
- Contractors’ failure in reducing waste from construction sites is due to lack of key drivers of waste management to reduce construction waste.
- Contractors are often confronted with inadequate construction waste management and sudden unable-to-reduce construction waste.
- Contractors fail in adopting adequate waste management practices and subsequently fail to manage waste in construction sites.
- Contractors’ waste management framework is not sustainable.

1.3 Research question

What are the effective waste management practices that need to be considered by contractors to reduce construction waste in the South African construction industry (SACI)?

1.3.1 Sub-questions

- What do contractors perceive as construction waste management in construction sites?
- What are the key drivers for contractor’s waste management practices in construction sites?
- What are the challenges experienced by contractors regarding the reduction of construction waste?
- What are the construction practices adopted by contractors to reduce construction waste?
- What effective construction waste management framework should be developed to aid the reduction of construction waste in South Africa?

1.4 Aim and objectives

The aim of this study is to develop a waste management framework to aid the reduction of construction waste in the SACI.

1.5 Objectives

- To investigate the perceptions of contractors regarding construction waste management in construction sites.
- To determine key drivers for contractors’ waste management practices in construction sites.
- To determine the challenges experienced by contractors regarding the reduction of construction waste.
- To determine the various construction practices adopted by contractors to reduce construction waste.
- To propose an effective framework for contractors to reduce construction waste in South Africa.

1.6 Context of the research

The study is based in South Africa and focuses primarily on the reduction of construction waste by contractors in the construction industry. The investigation will be conducted on construction contractors that deal with the recycling of construction waste. Lack of construction waste management is still one of the problems faced by many countries. South African landfills are very few and the ones available are often completely full. Some of the materials that are discarded at these landfills are harmful to the health of society, for instance asbestos, lead, mercury, polychlorinated biphenyls, chlorofluorocarbons, and radioactive sources.

1.7 Key assumptions

The research makes the following assumptions:

- The chosen construction contractors will take part.
- The chosen contractors will grant permission and supply pertinent information about construction waste management.
- The personnel working for the chosen contractors will supply pertinent information on survey questionnaires.

1.8 Contribution of the study

The study's findings will benefit the construction industry in the following ways:

- The main contribution is the development of an all-encompassing and useful framework intended especially to lower construction waste in South Africa.
- The study provides in-depth insights into the South African construction industry's particular challenges and opportunities in respect to construction waste management.
- The goal of the study is to assist contractors in implementing more sustainable practices by identifying and incorporating efficient waste management solutions.
- By reducing construction waste, the study aims to bring out the possible economic benefits for construction organisations, such as cost savings from reduced material usage and waste disposal expenses.

1.9 Limitations

- This study does not investigate contractors registered under cidb Grade 1 to 4;
- Data collection and quality are key factors in the accuracy and comprehensiveness of the study;
- The framework may not be as beneficial in other places, necessitating changes to local conditions that the study does not fully address; and
- Resistance to change, a lack of awareness, or insufficient buy-in from contractors may restrict the framework's effectiveness.

1.10 Research methodology

A quantitative research approach was adopted in this study to determine an effective construction waste management framework for the SACI. Creswell and Creswell (2018) concur that the quantitative research method is referred to as collecting numeric data and linking the data to existing theories and studies. Furthermore, Nardi (2018) classifies the quantitative research approach as the practice that a researcher presents collected data in numeric form. This study adopts a probability sampling technique using a random sampling. The targeted population for this study were contractors that are operating in the Eastern Cape province. The data used for this study was collected through primary and secondary sources of data collection. Descriptive statistics were used to distil the essential characteristics of the data to give brief summaries of the sample and the measurements. This involved computing means, medians, modes, standard deviations, and frequencies. The findings and inferences about the population based on the sample data were then reached using inferential statistics. To find out whether there were any statistically significant differences or correlations between the variables, methods like factor analysis and analysis of variance (ANOVA) were used. This was accomplished by presenting the study's findings and analysing the questionnaire data using the Statistical Package for Social Sciences (SPSS) version 29. Furthermore, the respondents' perceptions of the relative importance of the major elements influencing construction waste management were ranked using the Relative Importance Index (RII).

1.11 Division of chapters

Chapter one: This chapter introduces the study background, problem statement, research questions, objectives, aim of the study, significance of the study, preliminary literature, conceptual framework, and research methods which are detailed in this section.

Chapter two: This chapter focus on reviews of pertinent literature regarding the practical framework for lowering construction waste in South Africa. This chapter focuses on the following: perceptions of contractors regarding waste management in construction sites, key drivers for contractors' waste management practices in construction sites, challenges experienced by contractors regarding the reduction of construction waste, construction practices adopted by contractors to reduce construction waste, and an effective framework for contractors to reduce construction waste in South Africa.

Chapter three: The design and methodology for the data collection and analysis in this study are presented in this chapter. Furthermore, this part outlines the methods the study used to collect accurate data. It presents the methodology and approaches used by the researcher, including the design of the questionnaire, data analysis, and the population and sampling strategy used in the study.

Chapter four: This chapter focuses on the analysis and discussions of the collected data. It details the methods and techniques utilised for the data analysis, including statistical tools applied. The results of the analysis are presented in this chapter along with an explanation of their relevance to the goals or questions of the study. It contains graphic representations of the analysed findings, like tables, graphs, and charts. In addition, the findings highlight the financial advantages of efficient waste management techniques, though they were somewhat offset by concerns about disposal costs and the relative importance of short-term versus long-term returns. It was noted that some of the major obstacles impacting management attitudes were supervisors' poor communication, opposition to new waste reduction methods, and insufficient training. Seven important elements, such as poor communication, restricted access to recycling facilities, and inappropriate material reuse, were found via factor analysis to have an impact on waste reduction initiatives. Suggestions focused on how to maximise construction waste management in South Africa by integrating sustainable methods, resource efficiency, and change cultural attitudes toward zero-waste environments.

Chapter five: In this chapter conclusions and recommendations of findings and consequences are highlighted, which are derived from the findings of the study. Additionally, it contains suggestions for future studies that aim to overcome these limitation and further advance knowledge in the field.

1.12 Chapter conclusion

The background of the research study, the research problem, and the study's objectives are introduced in this chapter. The methods used are presented, along with the scope of the study and the main presumptions that guided it. This chapter established the framework for the subsequent chapters and provided the foundation for this dissertation. The review of studies of construction waste management strategies is discussed in the following chapters.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The analysis of the numerous literatures on construction waste as well as the implementations of several management strategies are presented in this chapter with the intention to understand the subject, the problem, and objectives of this study. Construction waste is a significant environmental challenge in many countries, including South Africa. Construction waste has adverse impacts on the environment, economy, and society. In South Africa, the construction industry is one of the largest waste generators. Efforts have been made globally to address construction waste by implementing frameworks and policies. This literature review provides an overview of the literature on effective frameworks to reduce construction waste in South Africa.

2.2 Sustainability

Sustainability is a comprehensive procedure that aims to restore and sustain the interaction between the natural and built environment, and to build communities that uphold fairness and human dignity (Aigbavboa *et al*., 2017). According to Dosumu and Aigbavboa (2019), contractors move towards sustainable construction which means moving away from reliance on landfills for waste disposal. Sustainable construction ensures the preservation of the environment as well as major development-related concerns, such as resource efficiency, constant social and economic growth, and the eradication of poverty (Dosumu & Aigbavboa, 2019). The construction industry creates a variety of physical facilities, such as dams, roads, bridges, residential and commercial buildings, factories, and recreational areas, which have an impact on society, the environment, and the economy (Durdyev *et al*., 2018). Abdel-Shafy and Mansour (2018) emphasised that, in order to improve sustainability in the construction industry, contractors must understand the need to minimise construction waste and adopt efficient waste management techniques on construction sites, such as on-site sorting, recycling, and material reuse. Dong and Ng (2015) noted the necessity for the construction team to use construction strategies that eliminate adverse environmental impact including pollution and carbon emissions.

Even though there have been several efforts to reduce and recycle construction waste, a sizeable portion of materials are still currently planned for disposal in landfills (Mbadugha *et al*., 2021). For instance, research by Blaisi (2019) found that substantial amounts of waste are disposed of in landfills despite the existence of regulations to minimise waste from construction sites. Furthermore, Alwan *et al*. (2017) recommends that waste reduction strategies be incorporated into the design and planning stages of construction projects, stressing the significance of using effective material management and sustainable construction techniques to reduce waste production at the source. Hence, Aigbavboa *et al*. (2017) summarised that the goal of sustainable construction is to minimise the negative environmental impact of construction while maximising the positive social and economic effects.

2.2.1 Waste management hierarchy

Waste management hierarchy serves as a structure that guides the prioritisation of waste management activities to attain the most sustainable results (Pires & Martinho, 2019). DEA (2018) lists the following waste management techniques in order of preference for the environment: prevention, minimisation, reuse, recycling, energy recovery, and disposal. Fei *et al*. (2021) state that prevention and minimisation work to stop waste production before it starts, save resources and lessen the impact on the environment. Reuse prolongs a product's life, whereas recycling turns waste into new materials (Tam *et al*., 2018). Janakova *et al*. (2024) defined energy recovery as the process of turning non-recyclable waste into fuel, power, or heat that can be used. There is a critical need to address the problem of c onstruction waste. One of the most effective ways to manage construction waste is to implement sustainable building practices, which prioritize social and economic concerns in addition to environmental ones (Akadiri et al., 2012). To combat the effects of construction waste on overall sustainable building, it is crucial to employ sustainable waste management (Nagapan *et al*., 2012). The waste management system in South Africa is structured around the waste hierarchy that was a hallmark of the 1999 National Waste Management Strategy (NWMS) (DEA, 2018). In response to persistent concerns about the growing volume of waste and the need for proper management, a number of policy measures, including the 4R's Principles (reduction of C&D waste are recover, reduce, re-use, and recycle), Site waste management plan, Waste management hierarchy, National Environmental Management Waste Act (NEMWA), Integrated Waste Management Plans (IWMPs), and Zero-waste approach, have been implemented (Van Wyk, 2014; Janse van Rensburg, 2022). Furthermore, Godfrey and Oelofse (2017) reveal that these policies seek to move waste management up the hierarchy toward reuse, recycling, and reduction. However, this study focuses on waste reduction in construction sites.

2.2.1.1 Reduce

Reducing waste is the most favoured management strategy and aimed to minimise the amount of construction waste and enable sustainable construction project delivery in SACI (Nyika et al., 2019). A comprehensive strategy that includes everything from early planning to on-site procedures and material management is needed to reduce construction waste (Purchase et al., 2021). According to Alwan et al. (2017), efficient design techniques, such the use of modular components and standard measurements, can drastically reduce waste and material off-cuts.

Jamil and Fathi (2018) noted that using Building Information Modelling (BIM) facilitates improved planning and visualisation, which aids in the early detection of possible waste sources. As recommended by Abubakar et al. (2022), waste segregation and recycling programmes, where materials are divided into categories like metal, wood, and concrete to promote recycling and reuse, are essential on-site initiatives. Frequent waste audits support production monitoring and identify opportunities for enhancement (Abdel-Shafy & Mansour, 2018). Additionally, utilising cutting-edge technologies like prefabrication and accurate cutting equipment will help reduce waste even more (Mbadugha et al., 2021). Waste can be drastically decreased by using sustainable procurement techniques, such as choosing eco-friendly products (Fei et al., 2021).

2.2.1.1.1 Contractors' awareness regarding construction waste

Hung and Kamaludin (2017) state that encouraging sustainable practices, cutting costs, and limiting environmental impact all depend on contractors being more conscious of construction waste management on construction sites. According to Nyika et al. (2019), contractors may only be properly equipped with the knowledge required for efficient waste management through education and training programmes like seminars and workshops. Nguyen (2022) suggests that contractors can be incentivised to comply with waste management standards and meet waste reduction targets through the implementation of incentive programmes and recognition systems. On-site waste management systems make it easier to handle construction waste properly (Abubakar et al., 2022). Examples of these systems include labelled containers for waste segregation and recycling stations (Abubakar et al., 2022). Udawatta et al. (2015) noted that teamwork and ongoing waste management practice development can be encouraged through regular meetings and a feedback mechanism.

2.2.1.1.2 Preventative measures

Another crucial strategy is to take preventative action. This means keeping materials in proper storage to avoid damage and overordering, as well as utilising cutting-edge construction procedures that reduce material waste (Ajayi et al., 2015). Preventative measures also involve regular equipment maintenance to ensure effectiveness and prevent unintended damage to materials (Ali et al., 2010). Furthermore, these issues can be found and fixed before they become waste with the help of thorough inspection procedures (Ali et al., 2010). According to Ng et al. (2018), employee training on safe material handling and storage techniques has a significant positive impact on waste reduction as well. Mbadugha et al. (2021) believe that developing a comprehensive site waste management plan will help to ensure systematic waste prevention and control throughout the project.

2.2.1.1.3 Innovative construction techniques

Abd Elkodous et al. (2022) suggest that employing cutting-edge construction procedures can result in a large reduction of waste. Mbadugha et al. (2021) addressed the off-site assembly methods that decrease waste and improve accuracy on-site including prefabrication and modular construction. Von Blottnitz et al. (2022) noted that reduced waste can also be achieved by implementing the principles of the circular economy, which emphasise the recycling or reuse of material after their useful lives are over. Cheng et al. (2022) point out that construction waste can be reduced by adopting lean construction approaches. According to Aboginije et al. (2020), the utilisation of green building materials and techniques can enhance sustainability and mitigate the ecological footprint of building projects.

2.2.1.2 Reuse

Reuse refers to repurposing products, resources, and parts from already-existing structures or earlier construction endeavours, with an emphasis on cost-effectiveness, sustainability, and waste reduction (Hasmori et al., 2020). Incorporating design concepts that enable future building component disassembly and reuse, along with salvaging resources from demolition sites such as bricks, wood, and metal, are some examples of this method (Bertino et al., 2021). Mbadugha et al. (2021) indicate that on-site reuse is using materials from the same project, for example excavated soil can be used again for landscaping. According to Tam et al. (2018), broken brick and concrete can be used as a sub-grade of the access road to the construction site. Furthermore, lifecycle assessments aid in the identification of reuse prospects, eliminating landfill waste and the need for new materials, therefore reducing the environmental impact (Li et al., 2019).

2.2.1.3 Recycling

Recycle strategy is described as a process of gathering old, re-used, and underused items that were formerly considered waste but were later transformed into useful new items (Gharfalkar et al., 2015). Nyika et al. (2019) noted that a lot of construction waste can be recycled. Frequently, aggregate and concrete products are made from recycled concrete and debris (Purchase et al., 2022). Steel, copper, and brass are all beneficial materials for recycling (Hasmori et al., 2020). Recycling of construction waste involves separating and recycling recoverable waste materials produced during construction and renovations (Bao & Lu, 2021). It involves the reprocessing of organic material but excludes energy recovery, reprocessing into fuel-grade materials, or reprocessing into materials for backfilling activities (Gharfalkar et al., 2015). Recycling construction waste is now the greenest method of treatment in terms of possible global warming

(Godfrey & Oelofse, 2017). Recycling construction waste not only reduces the need for landfill space but also lessens the use of natural resources and protects non-renewable ones (Godfrey & Oelofse, 2017). It should be noted that obtaining the needed behavioural change will be challenging without strong economic incentives guiding waste management toward recycling (Nzima & Ayesu-Koranteng, 2021). Often, compared to the virgin raw materials utilised by industry, secondary raw materials are more affordable (Yakubu & Zhou, 2017). Recycling of waste in South Africa is still lacking as only 11% and 7% of general and hazardous waste was able to be diverted in 2017 (DEA, 2018). More needs to be done to improve recycling and include it into the local economy to create green jobs and promote economic growth (Godfrey & Oelofse, 2017).

2.2.1.4 Recovery

After efforts to reduce, reuse, and recycle have been made, resource recovery takes place (Mbadugha et al., 2021). It comprises converting waste materials for the recovery of resources such as energy, heat, compost, and fuel, as well as metals, glass, and other materials, by thermal or biological methods (Musa et al., 2020).

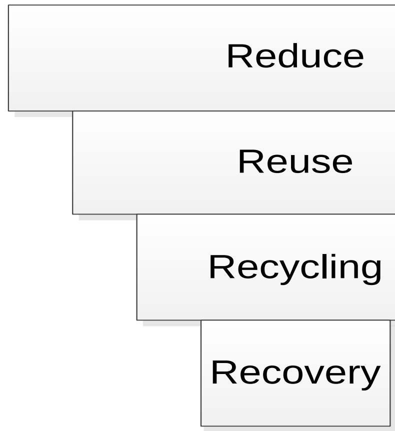

Figure 2.1 Waste management hierarchy (Adopted from Zhang *et al.,* 2022)

2.3 South African construction industry

The construction industry is crucial to South Africa's economy and is a major driver of economic expansion (Stats SA, 2010). Pheng and Hou (2019) are of the view that the construction industry is a crucial component of the economy since it creates buildings and other structures for civil engineering. Furthermore, Pheng and Hou (2019) add that it also determines how well investment efforts in a country with plenty of resources translate into real investment returns. The construction industry is a complex cluster of enterprises, comprising banking, companies that manufacture materials and equipment, firms that provide contracting services, and others (de Valence, 2019). Alaloul *et al*. (2022) state that the development of every country's socioeconomic system depends in large part on the construction industry. An important part of the national economy is contributed by the construction industry, which also generates jobs, contributes to the advancement and transfer of technology, opens a variety of business opportunities, and directly enhances the quality of life for those who use its products (Musarat *et al*., 2021). However, South Africa is faced with many challenges: one major one is waste management, which involves problems like scarce landfill area, strict enforcement of regulations, and expensive disposal cost (Nyika *et al*., 2019). The Department of Environmental Affairs (2018) noted that due to a lack of available land for disposal, South Africa confronts many difficulties in managing construction waste. Due to the nation's fast urbanisation, there is now much less area available for new landfills, and those that are already in place are rapidly filling up (Gumbi, 2015). This problem is made worse as construction waste affects the environment. Hazardous chemicals and materials can contaminate soil and water, disrupting local ecosystems and biodiversity (Sev, 2008). Waste management is further complicated by regulatory and policy difficulties; inefficiency and confusion are caused by inconsistent policies across different regions and by inadequate enforcement of current restrictions

(Abidin & Yusof, 2013). According to Ma *et al*. (2020), the absence of incentives and the high expenses of waste management procedures impede the adoption of sustainable practices by firms. Furthermore, a significant knowledge and information gap about sustainable waste management procedures exists among industry players, and worker training is inadequate (Meng *et al*., 2021). In social terms, the inappropriate handling of construction waste puts the health of the communities around it at danger, and locals frequently object to new waste facilities being built close to them (Abdel-Shafy & Mansour, 2018).

2.4 Construction waste

According to Okwesili and Iroko (2016), waste is any material that is discarded after serving its original purpose or that is broken, worthless, or otherwise unusable. The term is often subjective, because what is waste to one need not necessarily be waste to another (Kalkanis *et al*., 2022). Nyika *et al*. (2019) defined waste as anything that is unnecessary, disregarded, left behind, rejected, or undesirable. Any industrial production process produces waste. Numerous industrial methods result in varied wastes with a range of physical, mechanical, chemical, elemental and other qualities, including the ability to be hazardous, inert, or non-hazardous (Abdel-Shafy & Mansour, 2018). Waste that poses a threat to the environment or human health at least in part is deemed hazardous (Slack *et al*., 2005). Inert wastes do not change in a physical, chemical, or biological manner (Aksel & Cetiner, 2020).

With reference to the building industry, waste refers to a special stream of solid waste primarily produced by any kind of construction activities such as renovations, new building structures and deconstruction (Bao & Lu, 2021). According to the Department of Environmental Affairs, the construction waste stream accounts for about 40% of the country's total waste generation (DEA, 2018). Construction waste consists of masonry and concrete masonry units, all untreated wood, including lumber and finished products, wood sheet materials, wood trim, metals, roofing insulation, carpet and pad, gypsum board, unused (leftover) paint, piping, electrical conduit, packaging made of paper, cardboard, boxes, plastic, sheet, and film polystyrene packaging, wood crates, plastic pails, and beverage and packaged food containers (Purchase *et al*., 2021).

2.5 The perceptions of contractors regarding construction waste management

2.5.1 Cost concern

Efficient waste management techniques have been shown to yield long-term cost savings for contractors in the construction industry. Nagapan *et al*. (2012) highlight that adopting comprehensive waste management solutions not only reduces waste but also optimises material utilisation, lowering disposal costs. These findings align with Abubakar *et al*. (2022), who emphasize that sustainable waste management practices improve project sustainability and overall financial performance. However, the initial costs of implementing these techniques, such as setting up recycling facilities or training programs, often deter contractors despite the potential for long-term benefits (Polat *et al*., 2017). Waste disposal costs remain a major concern, particularly in regions with strict landfill regulations and high tipping fees (Durdyev *et al*., 2018). According to Nawaz *et al*. (2023), contractors frequently struggle to allocate labour and equipment resources to waste management, which can result in higher project costs and possible delays. Despite these challenges, Ghisellini *et al*. (2018) assert that integrating waste management into the project workflow can result in more efficient use of available resources, mitigating these concerns. A short-term perspective further exacerbates this issue, as contractors prioritize immediate cost savings over long-term financial and environmental advantages. Osmani *et al.* (2008) found that this approach often impedes the implementation of effective waste management techniques, ultimately affecting project cost efficiency. Contractors may also fear losing competitive bids if waste management increases project costs. Blismas and Wakefield (2008) revealed that many contractors perceive sustainable waste management as a potential threat to their competitiveness, deterring them from adopting such practices. Clients' financial constraints often compound these concerns. As Aboginije *et al*. (2020) and Chidobi (2022) noted that client budgets may limit investment in waste management systems, including compliance-related expenses such as permitting fees and regulatory adherence. While compliance with regulations incurs significant costs, Spišáková *et al*. (2021) argue that these investments are essential to avoid legal penalties and support sustainable construction practices. Additionally, the fluctuating costs of recycling and disposal services further complicate budgeting for waste management. Kabirifar *et al*. (2020) observed that contractors struggle to predict these variable expenses, creating uncertainty in waste management planning. Training workers on waste management practices and setting up sorting or recycling facilities also adds to project costs (Nyika *et al*., 2019). Despite these financial hurdles, Daian and Ozarska (2009) stress that investing in training and infrastructure ultimately leads to improved waste management outcomes and long-term project savings.

2.5.2 Management attitudes towards construction waste management

Management attitudes significantly influence the effectiveness of waste management practices on construction sites. The effectiveness of waste reduction initiatives is decreased when employees lack training programs, which frequently results in their ignorance of best practices (Osmani *et al.,* 2008). Insufficient training affects waste creation and disposal costs. Ajayi *et al.* (2015) highlight the significance of providing workers with the required skills. Accountability is another critical factor. Without clearly defined responsibilities, contractors face challenges in holding individuals accountable for waste management errors (Tafesse *et al*., 2022). Li *et al.* (2019) argue that this lack of accountability fosters inconsistent behaviours, undermining waste reduction efforts. Moreover, financial pressures and weak enforcement of regulations often lead to non-compliance, resulting in improper waste disposal and environmental harm (Gunningham & Sinclair, 2019; Chidobi, 2022). Effective communication by supervisors is vital for successful waste management implementation. Poor communication can create misunderstandings, leading to disregard for procedures and reduced compliance (Zorpas, 2020). Gamil and Rahman (2021) emphasize that clear and consistent communication ensures all team members understand their roles and responsibilities, facilitating better waste management practices. Inconsistent enforcement of waste management regulations further undermines reduction efforts. When enforcement is weak, workers may disregard procedures, which increases the amount of waste produced (Osmani *et al.,* 2008). Gangolells *et al.* (2014) stress that consistent enforcement is crucial to maintaining effective waste management systems. A prevalent issue in the construction industry is the preference for immediate cost savings above long-term sustainability. This short-sighted perspective has a detrimental effect on long-term project success and environmental sustainability, sometimes resulting in the abandonment of sustainable waste management solutions (Ajayi *et al*., 2017; Osmani *et al.,* 2008). For construction sites to have efficient waste management procedures, supervision is essential. Effective supervision is required to enforce rules and guarantee that employees adhere to set waste management protocols (Gangolells *et al.,* 2014). Ajayi and Oyedele (2018) stress that unmonitored locations are more likely to handle hazardous chemicals incorrectly or dispose of waste poorly, which can lead to waste-related safety hazards. Resistance to adopting novel waste reduction methods is another obstacle, as contractors may perceive these practices as risky or resource-intensive (Esa *et al.,* 2017). However, Osmani *et al.* (2008) suggest that showcasing the long-term benefits of innovative practices and providing education can help overcome this resistance. Contractors frequently believe that managing construction waste takes a lot of time and conflicts with other important project requirements. According to Nagapan *et al.* (2012), contractors are discouraged from adopting thorough waste management procedures because they believe doing so will cause project timeline delays. Ghisellini *et al.* (2018) contend that, in the long run, time can be saved by incorporating waste management strategies into the project workflow. Finally, project requirements significantly shape contractors' attitudes towards waste management. Osmani *et al.* (2008) found that projects with stringent waste management standards achieve better waste reduction outcomes. Similarly, Ajayi *et al.* (2017) observed that clear contractual specifications encourage contractors to adopt sustainable practices, prioritizing waste reduction throughout the project lifecycle.

2.5.3 Lack of training to reinforce the importance of waste management practices

An essential component of waste management is training, which guarantees that workers, contractors, and site occupants have the skills necessary to handle waste efficiently and in accordance with environmental regulations. Training programs must include a strong emphasis on managing hazardous waste and the dangers that come with it. Abarca-Guerrero (2017) highlights the need for addressing the environmental damage caused by improper disposal. While Ajayi *et al.* (2015) emphasise the necessity of specialised training programs to handle hazardous waste safely. Darko *et al.* (2017) similarly stress that training on environmental legislation and proper waste disposal methods is essential for reducing environmental risks and promoting compliance with waste management regulations. Comprehensive instruction on waste management laws is crucial to ensuring adherence to environmental policies and advancing sustainable practices. Ajayi *et al.* (2017) contend that to deter infractions and promote ecologically conscious behaviour, employees need to be properly trained on regulatory obligations. Insufficient training causes employees and site occupants to be ignorant of the risks associated with improper waste management, which can result in mishaps, injuries, and even environmental catastrophes. Safety training improves site safety and project results by assisting employees in identifying and reducing hazards related to hazardous materials (Hasmori *et al.,* 2020). In addition to ensuring compliance, efficient waste management necessitates increasing public awareness of resource waste and recycling and reuse alternatives. Ng *et al.* (2018) reveal that workers often discard valuable materials due to a lack of understanding about their potential for reuse, increasing project costs and exacerbating environmental harm. Training initiatives should highlight the financial and ecological benefits of recycling and reusing materials. According to Osmani *et al.* (2008), such programs foster a mindset of resource optimisation, which is critical for achieving sustainable construction practices. Instilling values of responsible waste management through ongoing training and education is another key element of successful waste management. Hasmori *et al.* (2020) emphasise that continuous training programs reinforce sustainable behaviours and ensure workers remain informed about best practices. Albarca-Guerrero (2017) adds that a neat and organised workplace not only encourages efficient waste disposal but also creates a safer environment for workers. Practical training in waste handling is indispensable for reducing waste production and encouraging safe behaviours. Ng *et al.* (2018) argue that training workers on proper handling techniques, such as segregating and storing waste, significantly improves operational efficiency. Moreover, Ajayi *et al.* (2017) highlight the importance of covering communication techniques in training programs to ensure effective coordination with subcontractors and other stakeholders.

2.6 Key drivers for contractors' waste management practices

The construction industry has significant negative effects on society in terms of the economy, the environment, and social issues (Zaman *et al*., 2020). Construction waste that has been improperly disposed of or illegally dumped may have an impact on biodiversity and wildlife by destroying natural habitats (Jones *et al*., 2020). Inadequately disposing of construction waste can pollute the soil, reducing its fertility and ability to support plant development (Siddiqua *et al*., 2022). Construction workers and the surrounding community may face health and safety issues if waste management practices are not followed properly (Nyika *et al*., 2019). The quality of life and wellbeing of those who live or work nearby are impacted by the noise and air pollution caused by construction activity (Abdel-Shafy & Mansour, 2018). The expenses of construction projects are increased by improper waste management since waste collection, transportation, and disposal require more resources (Tafesse *et al*., 2022). According to Onamade *et al*. (2022), organisations should concentrate on implementing sustainable waste management strategies, such as limiting waste generation, reusing resources, recycling, and responsible disposal, to lessen the impact of construction waste. Additionally, spreading knowledge about how construction waste should be handled among construction workers, businesses, and communities can help to reduce its impact (Abubakar *et al*., 2022).

2.6.1 Environmental sustainability

Maintaining ecological balance while protecting natural resources for future generations is the goal of environmental sustainability (Emina, 2021). However, the construction industry is frequently criticized for its unsustainable methods, which include substantial waste output and pollution (Aigbavboa *et al.*, 2017). The environmental effects of the construction industry, including the depletion of non-renewable resources and difficulties with waste management, are highlighted by (Ghisellini *et al*., 2018). Contractors must take steps to encourage environmental management, cut waste, and apply sustainable methods to address these problems (Mbadugha *et al*., 2021). Sustainable practices in the construction industry are strongly influenced by environmental restrictions. According to Ajayi *et al*. (2015) strict requirements force contractors to adopt better waste management practices. Mbadugha *et al*. (2021) pointed out that too strict regulations might cause logistical and financial difficulties, making it hard for contractors to comply. Policies should offer direction while assisting contractors with resources and incentives to fulfil regulatory obligations to strike a balance between enforcement and practicality. Enhancing environmental results requires the use of sustainable construction techniques, such as recycling materials and incorporating waste reduction plans into project plans (Nyika *et al*., 2019). Ezeah *et al*. (2013) warn that although these methods can cut expenses and waste, their full implementation is frequently hampered by a lack of funds and training. Although incorporating sustainability into building procedures costs a lot of money, there are long-term financial and environmental advantages. When it comes to building projects, resource efficiency maximizes material use and minimizes waste. Mbote *et al*. (2016) promote resource-efficient methods that improve environmental performance and project efficiency. However, contractors believe that these solutions are expensive and complicated, which discourages their use (Ajayi *et al*., 2017). Contractors can allay these worries by being informed about the long-term advantages of resource efficiency. Reducing waste and recycling are essential elements of sustainable construction. Coskun (2022) cites effective recycling initiatives in the construction industry that lower material costs and their negative effects on the environment. Nonetheless, Esa *et al*. (2017) stress the necessity of strong planning and infrastructure to support these activities, acknowledging the financial and logistical difficulties involved in maintaining efficient recycling systems. Maintaining ecological balance during construction requires protecting biodiversity. To preserve biodiversity, Sev (2009) highlights tactics including preserving natural habitats and minimizing land disturbance. Jones *et al.* (2020) contend that contractors frequently prioritise financial goals and project timelines over biodiversity conservation, underscoring the importance of stricter enforcement of environmental protections. Effective erosion and sedimentation control measures are crucial for preventing soil degradation and water pollution. Siddiqua *et al.* (2022) recommends employing stabilisation methods and sediment barriers to preserve soil and water quality. By incorporating these tactics into building procedures, long-term environmental sustainability is guaranteed. Carbon emissions and operating expenses are decreased when renewable energy technology is included into construction projects. While Perera *et al*. (2019) highlights the drawbacks, including high upfront costs and the requirement for specialized expertise. Ghisellini *et al*. (2018) show the environmental advantages of adopting renewable energy. Notwithstanding these obstacles, renewable energy makes a substantial contribution to lessening the environmental impact of construction projects. Hazardous material handling must be done correctly to preserve safety and avoid contamination. Purchase *et al*. (2021) stress that to reduce dangers, proper handling, storage, and disposal techniques are crucial. Kang *et al*. (2022) emphasise the difficulties associated with managing hazardous materials, including the requirement for specialised training and the risk of accidental leaks. Energy-efficient construction methods help minimise energy consumption and lower greenhouse gas emissions.

According to Ferrara *et al*. (2016), there are major financial and environmental advantages to implementing energy-efficient designs and technology. However, Mulu (2021) points to obstacles including the high initial price and the specialized materials needed for energy-efficient buildings. Sustainable construction involves implementing water-saving measures such as rainwater harvesting, greywater reuse, and efficient irrigation systems. These strategies can reduce water consumption and improve resource efficiency (Ajayi *et al*., 2016). Burger and Gochfeld (2016) highlight the necessity of site-specific planning while pointing out the financial and technical difficulties in putting these systems into place. Long-term environmental sustainability depends on cleaning up contaminated soil and returning building sites to their original form. Despite their effectiveness, remediation approaches are frequently costly and technically demanding (Gochfeld, 2016). To choose suitable cleanup techniques that strike a balance between environmental and budgetary concerns, contractors must assess site-specific elements. Utilizing dust suppression techniques and low-emission equipment are two examples of air pollution control measures that enhance air quality and lessen the environmental impact of construction. While Manisalidis *et al*. (2020) highlight the difficulties in incorporating air pollution management into current procedures, such as high costs and operational disruptions. Abdel-Shafy and Mansour (2018) show how beneficial such techniques are in lowering emissions. To handle the effects of harsh weather and shifting environmental circumstances, it is becoming more and more crucial for building projects to plan for climate resilience. To guarantee project longevity and environmental sustainability, contractors are implementing tactics including improved drainage systems, flood mitigation, and resilient material selection (Siddiqua *et al*., 2022).

2.6.2 Economic sustainability

Economic sustainability helps contractors maximize resources, cut costs, and maintain their competitiveness, which is a major driver for waste management methods. Disposal costs are a significant determinant of waste management choices, and they can be especially onerous in cities with constrained landfill space and expensive tipping fees (Ajayi *et al*., 2015). Recycling provides a practical substitute, reducing disposal expenses and producing income from the sale of recyclables. Recycling helps achieve environmental objectives while also lowering disposal costs (Nyika *et al*., 2019). Effective waste segregation and recycling initiatives are made more difficult for contractors by the absence of readily available recycling facilities (Abubakar *et al*., 2022). Rising construction material costs further compel contractors to adopt strategies to reduce waste and enhance resource efficiency. Nyika *et al*. (2019) suggest that employing approaches like just-in-time delivery and accurate inventory management can help mitigate procurement costs. Such strategies ensure efficient material use while minimising overordering and waste (Osmani *et al*., 2008). The cost of regulatory compliance is another important factor to consider because following waste management standards usually entails spending money on permits, audits, and the infrastructure that is required. Notwithstanding these costs, Ajayi *et al.* (2015) contend that, over time, compliance saves money by assisting contractors in avoiding fines and legal repercussions. Additionally, contractors' reputations are strengthened by fulfilling regulatory standards, which raises their credibility and trust in the marketplace (Abidin & Yusof, 2013). Market competition and the need for differentiation also drive contractors to adopt sustainable practices. Implementing effective waste management not only improves environmental performance but also provides a competitive advantage by appealing to environmentally conscious clients (Mbadugha *et al*., 2021). Sustainable practices, coupled with regulatory compliance, enhance brand reputation and foster stakeholder confidence (Abobinije *et al*., 2020). Despite the advantages of sustainable waste management, limited project budgets often restrict contractors' ability to invest in comprehensive programs. Contractors may prioritize short-term cost savings above long-term sustainability due to tight budgets (Nawaz *et al*., 2023). However, these financial strains can be lessened with the use of financial assistance systems like tax incentives. Contractors are encouraged to use sustainable waste management systems by policies that grant tax credits or incentives for implementing sustainable activities, such as recycling or utilizing eco-friendly products (Liu *et al*., 2020). Long-term sustainability and significant cost savings are fostered by contractors who integrate resource-efficient methods, recycling, and trash audits into their workflows. Regular waste audits, as noted by Durdyev *et al.* (2018), help identify waste streams and minimise unnecessary material usage. Additionally, purchasing materials in bulk and opting for eco-friendly options reduce both procurement and disposal costs, further improving financial outcomes (Aigbavboa *et al*., 2017). Nagapan *et al*. (2012) conclude that contractors who implement effective waste management not only lower operational costs but also cultivate a culture of continuous innovation and improvement, ensuring their success in a market increasingly prioritising environmental sustainability.

2.6.3 Social sustainability

In the construction sector, social sustainability pertains to making sure that the laws and practices put in place not only handle environmental issues but also advance the welfare of workers and communities, especially when it comes to waste management (Fei *et al*., 2021). Nyika *et al*. (2019) opine that effective construction waste management can greatly improve social sustainability by fostering safer and healthier work environments. On the other hand, Abdel-Shafy and Mansour (2018) reveal that treating construction waste properly lowers the chance of accidents and health problems brought on by exposure to hazardous materials. Encouraging workers to practise waste segregation and recycling on-site fosters a culture of accountability and environmental stewardship, which enhances their general job satisfaction and well-being (Tafesse *et al*., 2022). An additional crucial component of social sustainability in construction waste management is the benefits to the community. The Department of Environmental Affairs (2018) draws the conclusion that initiatives that put an emphasis on recycling, reusing, and decreasing construction waste can benefit nearby communities by lessening the load on their waste disposal infrastructure and lowering pollution levels. To preserve the environment and public health, governments and regulatory agencies set waste management guidelines (Kabirifar *et al*., 2020). Contractors' on-site waste management is influenced by regulations, which may include mandated recycling quotas, waste disposal procedures, and sanctions for non-compliance (Ajayi *et al*., 2015). The general public's understanding of waste management and environmental issues has increased dramatically in recent years. Increased accountability and transparency in waste management procedures can result from public pressure (Mirtl *et al*., 2018). According to Kabirifar *et al*. (2020), contractors can enhance their public support and reputation in a market that is becoming more socially conscious by demonstrating their commitment to sustainable waste management. Abubakar *et al*. (2022) add that contractors often work in conjunction with community organisations to develop and implement waste management initiatives that are tailored to the specific needs and preferences of the local area. According to Kabirifar *et al*. (2020), contractors must follow these guidelines to stay credible and competitive in the market. Mbadugha *et al*. (2021) note that standards frequently offer recommendations for recycling, responsible disposal, and waste reduction, which aids contractors in putting into practice efficient waste management techniques. Sustainable practices and ethical waste management are becoming more important to clients, investors, and shareholders when it comes to project needs (Zhao, 2021). Positive change may be pushed by a workforce that is dedicated to responsible waste management and values sustainability (Shooshtarian *et al*., 2020). A motivated workforce that actively contributes to waste reduction and recycling initiatives is advantageous to contractors (Mbadugha *et al.,* 2021). Enhancing waste management procedures in the construction industry requires educational programmes. To improve awareness and increase understanding about efficient waste management techniques, these initiatives may include formal training programmes, workshops, and educational campaigns (Dosumu & Aigbavboa, 2021). According to Fei *et al*. (2021), education plays a crucial role in assisting contractors and their staff in comprehending the significance of waste reduction, the advantages of recycling, and the environmental consequences of their actions.

2.7 Challenges experienced by contractors regarding the reduction of construction waste

Lack of specific waste reduction goals and targets is one of the biggest issues contractors deal with. It is hard to monitor progress and make wise waste management decisions in the absence of clear, quantifiable targets (Osmani *et al*., 2008). Ajayi *et al*. (2015) suggest that contractors can better allocate resources and prioritise waste reduction projects when they have clear targets. Udawatta *et al*. (2015) contend that contractors are unable to effectively reduce waste because they rely on haphazard and ineffective waste management techniques in the absence of a well-structured plan. Hasmori *et al*. (2020) point out problems that can prevent the development of efficient waste management solutions, including a lack of time, money, and competence. One major difficulty is choosing building materials without fully understanding the ramifications of their waste. Sustainable procurement strategies that consider the lifecycle of materials as well as their potential for recycling and reuse are crucial (Ajayi & Oyedele, 2018). Abdel-Shafy and Mansour (2018) pointed out that to understand the types and quantities of waste generated on-site, regular waste audits are essential. Abdel-Shafy and Mansour (2018), claim that precise information gathered through audits offers insightful information that can help make better decisions and enhance waste management procedures. Source separation is essential for maximising recycling rates and minimising contamination of recyclable materials (Nyika *et al*., 2019). But logistical issues, space constraints, and poor infrastructure frequently cause contractors to struggle with this (Bajjou *et al.,* 2017). According to Gangolells *et al.* (2014), a major obstacle to waste reduction is the lack of on-site recycling facilities. While Tafesse *et al.* (2022) recognizes the advantages of on-site recycling facilities, they also draw attention to the practicality and financial concerns surrounding their deployment.

Jamil and Fathi (2018) highlighted that lean construction concepts are beneficial for efficiency and waste reduction. Cheng *et al.* (2022) draw attention to the difficulties contractors encounters while implementing lean construction concepts, including reluctance to modify, inadequate training, and the perception of complexity. According to Liu *et al*. (2020), deconstruction can drastically save waste and produce useful materials for upcoming projects. Reusing materials correctly on-site has several advantages, including lower waste and economic savings (Mohan *et al*., 2015). Osmani *et al.* (2008) highlight the difficulties in putting recommended practices for appropriate material reuse into practice. According to Tafesse *et al*. (2022), knowledge about neighbouring recycling facilities is essential for efficient waste management. According to Tafesse *et al.* (2022), contractors can lower disposal costs and increase recycling rates by utilising a thorough database of nearby recycling providers. The advantages of sustainable buying practices, including less waste and environmental effect, are emphasised by Yu *et al*. (2021). On the other hand, Kabirifar *et al*. (2020) draw attention to the financial factors that may discourage contractors from using sustainable procurement techniques. According to Udawatta *et al*. (2015), more sustainable practices may result from raising public knowledge of the advantages and techniques of waste reduction. Ajayi *et al.* (2015) note that contractors may find it challenging to fund awareness campaigns and instructional initiatives due to a lack of funding and conflicting objectives. Osmani *et al*. (2008) point out that training can give employees the abilities and information needed for sustainable waste management. Bajjou *et al.* (2017) argue that the success of training projects can be hampered by problems including scarce resources, time constraints, and the requirement for continual education.

According to Bajjou *et al.* (2017), there is a rise in waste due to the challenge of sorting and preserving recyclable items in small spaces. To increase recycling rates and waste management efficiency, Abubakar *et al.* (2022) highlight the advantages of stringent waste segregation requirements. Poor supervision, worker opposition, and poor training can all impede the successful application of segregation techniques (Portny & Portny, 2022). Nawaz *et al.* (2023) noted that it is difficult to handle waste in an orderly and effective way without enough storage capacity. Hasmori *et al.* (2020) point out that time constraints, a lack of experience, and a lack of resources are some of the obstacles to creating thorough waste reduction programmes. Regular updates and unambiguous instructions can assist to guarantee that employees are aware of their roles and duties in waste management (Osmani *et al.,* 2008). According to Zorpas (2020), it can be challenging to create and maintain clear communication channels due to high turnover rates, language hurdles, and the fast-paced nature of building projects.

Ponnada and Ponnada (2015) indicate that inefficiencies and increased waste output result from contractors lacking the equipment and apparatus necessary to handle and process waste.

Mbadugha *et al*. (2021) emphasise the significance of making an investment in cutting-edge, effective waste management technology. For waste management to be effective, tracking waste on-site is essential. However, many contractors struggle to effectively monitor and report waste generation and disposal (Bajjou *et al*., 2017). Lu *et al*. (2017) contends that by offering precise data on waste generation and disposal, cutting-edge tracking systems and technology may greatly enhance waste management methods. It is important to encourage a sustainable culture in the construction sector (Abarca-Guerrero *et al*., 2017). According to Yu *et al*. (2021), contractors may overlook sustainable standards due to economic demands. Ajayi *et al*. (2015) contend that encouraging a zero-waste culture on construction sites requires the implementation of zero-waste rules and training initiatives. According to Yu *et al.* (2021), adopting a zero-waste attitude might be difficult due to ingrained habits and behaviours as well as a lack of understanding. Osmani *et al.* (2008) emphasise the importance of clearly defining roles and responsibilities for waste management on construction worksites. Yu *et al.* (2021) points out that tight timelines and budget constraints can make it challenging for contractors to prioritise waste reduction over project completion.

According to Albarca-Guerrero *et al.* (2017), contractors may find it difficult to recycle materials and minimise waste if they lack simple access to recycling solutions. In the absence of a comprehensive waste management system, Abubakar *et al.* (2022) point out that contractors might find it difficult to put into practice reliable and efficient procedures. Reduced waste creation and environmental effect result from contractors' frequent preference for production and project completion over waste minimisation (Ajayi *et al.,* 2015). One major obstacle to the implementation of waste reduction strategies is cost-related difficulties. Abarca-Guerrero *et al*. (2017) contend that financial incentives and long-term cost reductions should be shown to help contractors get past financial obstacles in the way of implementing waste reduction techniques.

2.7.1 Design and planning

Mbote *et al*. (2016) consider project designs that do not follow specifications or modular dimensions as a significant source of construction waste. Waste can result from the excessive ordering of materials which is caused by inaccurately poor planning (Darko *et al*., 2017). Ikau *et al*. (2016) claim that waste is rarely produced during the early stages of design, even though around one-third of construction waste may result from design choices. Doloi *et al*. (2012) pointed out that it is crucial to incorporate efficient waste reduction strategies early in the design phase even though contractors usually have limited influence over the first design choices made by architects and engineers. This may result in lost chances to choose supplies and procedures that reduce waste production (Doloi *et al*., 2012). Furthermore, according to Hasmori *et al*. (2020), creating and carrying out thorough waste management plans is the responsibility of contractors. Hasmori *et al*. (2020) further explained that these plans need to specify how various waste types will be managed, stored, disposed of, or recycled, which calls for careful planning and organisation. Most waste management efforts are typically concentrated on the construction stage, even though design-stage initiatives have a considerable impact on project outcomes (Shooshtarian *et al*., 2020). However, Bilal *et al*. (2016) notes that instructions that are unclear or ambiguous might result in misunderstandings and inefficient resource use. Mbadugha *et al*. (2021) argue that delays in communicating project updates or modifications could result in unnecessary material orders. Thus, it is recognised that design-related actions, like the use of prefabrication techniques, modular construction, sustainable material selection, and Building Information Modeling (BIM) could significantly reduce waste produced during construction (Ajayi & Oyedele, 2018).

2.7.2 Material selection

Contractors face difficulties in material selection, which begins with using project specifications and drawings to order construction materials (Chidiobi, 2022). Chidiobi (2022) noted that correct interpretation of these documents is essential since inaccuracies or omissions may result in the ordering of additional or incorrect materials, which increase waste. Solanke (2015) pointed out that it is difficult for a contractor to make sure they order materials that satisfy the sustainability requirements as the contractor has no power to change the specification of the drawing. Hasmori *et al*. (2020) adds that the contractor needs to precisely estimate the amounts of materials required on a construction project based on the specification and drawings. Ajayi *et al*. (2017) argue that substantial waste can result from ordering too many materials. According to Jamil and Fathi (2018), the implementation of Building Information Modelling (BIM) can aid in reducing these problems by facilitating more accurate ordering procedures and offering accurate material quantification. Further, efficient communication and coordination among all stakeholders are crucial to guarantee that material orders correspond with project updates and adjustments (Onamade *et al*., 2022).

2.7.3 Logistics

Waste management on construction sites is made much more difficult by logistics issues. As per Kang *et al*. (2022) it takes careful coordination with waste management companies to organise timely pickups and deliveries to transport waste to recycling facilities or disposal locations efficiently. Asimakopoulos *et al*. (2015) added that the process can be made more difficult by variables including traffic, site access limitations, and regulatory compliance; therefore, efficient scheduling and route planning are required to reduce delays. Furthermore, Akadiri *et al*. (2012) pointed out that on-site coordination between different trades and subcontractors is essential for effective waste management. However, Zorpas (2020) noted that it is crucial to have regular meetings and maintain open lines of communication to guarantee that everyone follows waste management procedures and avoids incorrect disposal and contaminating recyclables.

2.7.4 Labour training

Contractors frequently confront considerable obstacles in this area, even though efficient labour training is essential for controlling construction waste on sites (Nyika *et al*., 2019). Zhao (2021) pointed out that ensuring that every employee is aware of and follows waste management procedures is a significant task. Zhao (2021) further noted that it involves teaching them how to use resources wisely, correctly sort and dispose of waste, and adhere to the sustainable practices specified in the waste management plan. According to Polat *et al*. (2017), one more difficulty is dealing with workers who are used to old construction method of just dumping waste without considering it for reuse or recycling and their tendency to be resistant to change. A study by Shooshtarian *et al*. (2020) reveals that long-standing behaviours and attitudes need to be changed, and management must continue to support and encourage this effort in addition to providing training. According to Onamade *et al*. (2022), construction waste can be reduced on construction sites if contractors can promote a sustainable culture that views waste reduction as a shared duty.

2.7.5 Change orders

Contractors face considerable difficulties in controlling construction waste on sites because of change orders (Polat *et al*., 2017). Mbadugha *et al*. (2021) add that different materials or quantities than first anticipated are frequently required because of these modifications to the original project scope or design. Chen *et al*. (2020) highlighted those postponements in sharing project updates or changes is the major challenge and it results in unnecessary material orders, which would buy extra materials, hold them, and then throw them away if they are not needed or returned. According to Onamade *et al*. (2022), strong communication channels are essential for all parties involved in the project to be swiftly notified of changes and be able to modify their plans accordingly. Mbadugha *et al*. (2021) concluded that the alignment of the project management team, suppliers, subcontractors, and on-site employees is necessary to reduce the waste that comes with change orders.

2.7.6 Regulatory compliance

Regulatory compliance is one of the main barriers to contractors managing construction waste on sites efficiently. According to Kim *et al*. (2006), one of the main challenges in waste minimisation processes is the government's failure to impose regulations on waste management and inadequate codes of practice, despite the government's obligation to ensure the implementation of a sustainable waste management system in construction projects. Additionally, Fischer (2011) concludes that there are specific obstacles to overcome to provide a sustainable waste management system in the construction business. For example, the financial strain on a municipality resulting from waste management issues might exacerbate other issues if the difficulties are not overcome. A few of these obstacles are the complexity of waste management, the participation of numerous parties, the difficulty associated with recovering costs, and the absence of necessary waste management expertise (Ponnada & Ponnada, 2015).

2.7.7 Lack of data

Creating efficient waste management programmes requires precise and thorough data on waste generation, handling, and disposal (Yuan, 2017). Nyika *et al.* (2019) pointed out that precise knowledge about the number of materials required at various stages of a project can help avoid overordering, which lowers waste. Yakubu and Zhou (2017) added that information about recyclable materials can be used to create effective recycling procedures. Liphadzi (2022) indicates that gathering and interpreting construction waste data calls for resources and knowledge that many South African contractors might not have. Enhancing waste management procedures requires spending money on data management systems and spending time and money training employees on how to utilise them (Nagapan *et al*., 2012). Zaman *et al*. (2020) state that contractors need to have strong data gathering systems in place to monitor the rates of waste generation, disposal, and recycling to meet this issue.

2.7.8 Contractors' material handling practices

Efficient material handling is essential for reducing waste although many contractors struggle to ensure that materials are handled, stored, and used effectively (Mulu, 2021). Nawaz *et al*. (2023) added that improper material storage can result in deterioration and damage. Akadiri *et al*. (2012) state that building materials frequently need certain storage circumstances to preserve their quality, such as weather protection and well-organised storage to guard against physical damage. Indeed, Abarca-Guerrero (2017) noted that if these requirements are not met, there may be more waste produced since broken items must frequently be thrown away. Aboginije (2020) added that lack of uniform material handling practices among employees is a challenge as waste and inefficiencies might result from irregular material handling and use procedures.

2.7.9 Over allowances in material

Sweis *et al*. (2021) indicated that contractors face considerable difficulties in controlling construction waste on construction sites because of over allowances in material ordering. This is supported by Mbadugha *et al*. (2021) who reveals that contractors frequently buy extra materials, more than are necessary, to allow for errors, damages, or unanticipated changes in the project scope. Although this approach attempts to reduce risks and prevent project delays, it may result in excessive waste if these extra materials are not needed before the project's conclusion (Mbadugha *et al*., 2021). Mbote and Makworo (2018) noted that overordering leads to both financial and environmental inefficiencies. McNamara and Sepasgozar (2021) add that contractors are faced with managing project demands that are unclear and variable material usage, which is frequently made worse by imprecise data on material requirements that results in conservative estimates and overstocking.

2.7.10 Contractors’ attitude regarding waste management on site

Kulatunga *et al*. (2006) noted one major obstacle to efficiently managing and reducing construction waste on sites as the attitudes of contractors regarding waste management. Hung and Kamaludin (2017) argue that effective application of waste reduction measures requires a favourable attitude toward sustainable activities. On the other hand, a lot of contractors tend to view waste management as a secondary issue, less important than keeping project budgets and deadline on track. This belief frequently results in a lack of funding for waste management programmes, poor worker training, and lax enforcement of waste segregation laws (Portny & Portny, 2022). Revell and Blackburn (2007) argue that the problem is made worse for contractors that view waste management as an extra expense that comes with no immediate, noticeable advantages. Indeed, Ghaffar *et al*. (2020) believe that efforts to execute efficient waste management methods are frequently hindered in the absence of contractors' active engagement and dedication. Ghaffar *et al*. (2020) further conclude that there are long-term advantages to appropriate waste management, such as financial savings from less material waste, adherence to environmental laws, and the possibility of improved company reputation.

2.8 Construction waste management

The construction industry produces a lot of waste, and more than half of it is dumped in landfills (Siregar & Kustiani, 2021). Onamade *et al*. (2022) noted that promoting construction waste management strategies is necessary because cities are producing more construction waste because of urbanisation, rapid economic growth, and the necessity for extensive construction to accommodate the teeming population. Bakchan and Faust (2019) argue that the waste produced by the construction industry has negative effects on the environment and the economy. Oke *et al*. (2019) state that proper management of the excess waste produced by the construction industry can lead to effective usage of some, and reduction in the pressure on the limited available earth resources consumed by the industry. Kulatunga *et al*. (2006) observed that the generation and implementation of waste management techniques can be influenced by the attitudes and perceptions of construction workers. Reuse and recycling of waste is considered an alternative way to help reduce the amount of construction waste. However, there are negative perceptions by the contractors of recycled materials which include that they are difficult to use and result in inferior constructions (Mohan *et al*., 2015). Delaware (2003) pointed out that the reliability of used material is one concern that arises from the secondary use of construction waste, which brings about some scepticism in the use of thereof. According to Nyika *et al*. (2019), the problem with waste reduction persists because waste management in construction sites is not well-practised in the South African construction industry. Public production of construction waste has increased in recent years because of rising demand and ongoing global growth. It is widely acknowledged that steps must be taken to regulate the amount of construction waste generated and the way it is dumped (Mbadugha *et al*., 2021). Several best practices have been identified globally to reduce construction waste. These include the use of lean construction principles, pre-construction planning, waste management plans, building information modelling (BIM), prefabrication, and green building practices. It is believed that proper implementation of these strategies can reduce the waste related challenges that SACI is currently facing (Jamil & Fathi, 2018).

Legal compliance and the preservation of the environment depend on adherence to the National Environmental Management: Waste Act of 2008. Frequent inspections pinpoint areas in need of development and guarantee adherence to best practices (Choudhry, 2014). Esa *et al*. (2017) noted that an environment of waste minimisation and compliance is promoted by management and employee training and awareness initiatives. According to Mbote *et al*. (2016), reusing resources and improving designs are two tactics that can be used to efficiently limit waste. Lu *et* *al*. (2017) reveals that efficiency and openness are increased via precise waste tracking and reporting systems. Onamade *et al.* (2022) believe that waste audits and baseline assessments assist in assessing present procedures and identifying potential for improved waste management, on-site sorting and that recycling lowers landfill waste and disposal expenses.

2.8.1 Onsite construction waste management

The construction industry has implemented a variety of waste management strategies and tactics, with efficient waste management becoming more widely acknowledged as a crucial indicator of operational success (Ajayi *et al.,* 2015). Construction waste management initiatives must be guided by well-defined waste reduction targets and objectives. According to Mbadugha *et al.* (2021), contractors can monitor progress and uphold responsibility when objectives are well-defined. According to Durdyev *et al.* (2018), setting clear goals encourages stakeholders to use more effective waste management techniques, which enhances project results. Understanding the kinds and amounts of waste produced on construction sites requires conducting a waste audit and baseline assessment. Yuan (2017) emphasizes that thorough audits assist project managers in pinpointing areas that require improvement and identifying significant waste streams. These initial assessments provide a benchmark for evaluating the success of waste management plans over time (Spišáková *et al.,* 2021). Moreover, adopting waste minimisation techniques such as modular construction, prefabrication, and just-in-time delivery has significantly reduced waste generation (Hasmori *et al.,* 2020). Choosing durable, recyclable materials with minimal environmental impact can also substantially lower waste levels, as noted by Chidiobi (2022) and Ajayi *et al.* (2017). Materials with extended lifespans further contribute to waste reduction by minimising replacement frequency.

On-site sorting and recycling are integral to effective waste management. Abdel-Shafy and Mansour (2018) observe that establishing designated areas for sorting different waste types improves recycling rates and reduces contamination. Recycling materials directly on-site not only decreases disposal costs but also diverts waste from landfills, creating both economic and environmental benefits (Abubakar *et al.,* 2022). For example, reusable materials such as bricks, tiles, and slates can be repurposed in future projects, conserving resources (Bertino *et al.,* 2021). Training and awareness among management and workers are vital for promoting best practices in waste management. Nyika *et al.* (2019) emphasise that well-structured training programmes ensure employees understand the significance of waste management and follow established procedures. Hasmori *et al.* (2020) add that continuous education and awareness campaigns result in more consistent and effective waste management. Additionally, implementing waste tracking and reporting systems is essential for identifying trends and areas requiring improvement. Lu *et al.* (2017) suggest that detailed records of waste production and disposal enable data-driven decisions and enhance waste management strategies. Compliance with legal regulations is another important aspect of managing construction waste responsibly. Adhering to local, regional, and national waste management laws safeguards contractors from potential penalties and reputational damage (Kabirifar *et al.,* 2020). According to Dosumu and Aigbavboa (2022), rigorous adherence fosters stakeholder confidence and responsibility. Post-construction waste assessments are essential for determining areas for improvement and assessing how well waste management techniques are working (Abubakar *et al.,* 2022). Another important factor in guaranteeing compliance with waste management strategies is routine site inspections. Udawatta *et al.* (2015) state that inspections help detect deviations and enforce waste management protocols. Choudhry (2014) adds that these inspections facilitate prompt corrective actions, maintaining high standards of waste management throughout the project lifecycle.

2.8.2 Procurement

Procurement entails acquiring goods and services in ways that minimise waste generation and promote recycling. Ajayi *et al.* (2016) define procurement as a strategic process that integrates waste management into construction operations, focusing on sustainable material selection and efficient waste treatment solutions. Bakchan and Faust (2019) emphasise that effective procurement reduces the environmental impact of construction by prioritising eco-friendly practices and ensuring adherence to regional regulations and environmental standards. Incorporating waste reduction strategies within procurement enables construction projects to optimise resource use and significantly lower their environmental footprint (Ruparathna & Hewage, 2013). One essential procurement strategy is just-in-time delivery, which ensures materials arrive only when needed, thereby reducing storage challenges, material degradation, and waste (Mbote & Makworo, 2018). This method helps contractors streamline processes while preventing the accumulation of unnecessary waste. Additionally, bulk purchasing minimises packaging waste and reduces procurement costs, supporting more sustainable construction practices (Ghaffar *et al.,* 2020).

Local sourcing also plays a key role in minimising transport-related waste and emissions, contributing to environmental sustainability while bolstering local economies. Gálvez-Martos *et al.* (2018) underline the dual benefits of reducing a project's carbon footprint and promoting regional economic development through local procurement. Quality assurance during procurement is critical to waste reduction. Ajayi *et al.* (2016) highlight that ensuring materials meet project specifications minimises the need for rework, thereby reducing waste generation. Furthermore, collaborating with suppliers committed to sustainable practices enhances waste reduction efforts. Partnering with suppliers who prioritise reusable or minimal packaging fosters a sustainable supply chain and significantly decreases packaging waste (Onamade *et al.,* 2022). Regular waste audits are another integral component of procurement, enabling ongoing improvement of waste management practices. These audits provide valuable insights into waste generation trends, helping contractors identify inefficiencies and refine strategies (Abdel-Shafy & Mansour, 2018). Effective inventory management further complements these efforts by ensuring materials are ordered and used efficiently, preventing overordering, spoilage, and unnecessary waste (Ajayi *et al.,* 2016).

2.8.3 Handling

Handling encompasses essential processes aimed at managing construction site waste effectively. Williams (2023) defines handling as the systematic collection, sorting, transportation, and disposal of waste materials. Bajjou *et al.* (2017) expand on this, describing it as a process that enhances source separation, recycling, and reuse, significantly reducing the volume of waste destined for landfills or incineration. This approach aligns with sustainability goals by promoting efficient material storage, responsible resource usage, and environmentally sound waste management practices (Njoku & Edokpayi, 2023; Mbote *et al.,* 2016). Training in safe material handling plays a crucial role in preventing accidents and minimising material damage. Darko *et al.* (2017) highlight that well-trained workers are more capable of handling materials safely and efficiently. Adhering to quality standards further minimises the risk of rework, which helps to reduce waste (Sev, 2009). Moreover, effective on-site organisation and storage prevent material deterioration and loss, supporting waste reduction initiatives (Abubakar *et al.,* 2022). Reusing materials whenever feasible is another cornerstone of sustainable handling practices. Aboginije (2020) notes that reusing materials not only cuts down on waste but also generates cost savings. Items like concrete and steel can be incorporated into recycling programs for future use, diverting them from landfills (Njoku & Edokpayi, 2023). Proper handling techniques ensure materials are stored, transported, and utilised in ways that minimise damage and waste (Njoku & Edokpayi, 2023). Comprehensive waste tracking and record-keeping enhance waste management by providing data on waste generation patterns, enabling contractors to pinpoint inefficiencies and improve strategies (Lu *et al.*, 2017). These systems optimise handling practices, ensuring every stage aligns with sustainability objectives. Ongoing worker training in material handling techniques is vital for maintaining best practices and addressing emerging challenges. Regular training fosters a culture of accountability and ensures adherence to high waste management standards (Abarca-Guerrero *et al.,* 2017). Additionally, separating materials at the source facilitates recycling and streamlines waste management, contributing to the project's overall sustainability (Ng *et al.,* 2018).

2.8.4 Operation

Handling encompasses essential procedures designed to efficiently manage waste produced on construction sites. According to Williams (2023), it involves the systematic processes of collecting, sorting, transporting, and disposing of various waste materials. Bajjou *et al.* (2017) expand this definition by highlighting the role of handling in enhancing source separation, recycling, and reuse, which significantly reduces the amount of waste directed to landfills or incineration. This approach supports sustainability objectives by encouraging efficient material storage, responsible resource utilisation, and environmentally sound waste management practices (Njoku & Edokpayi, 2023; Mbote *et al.,* 2016). Safe material handling training is crucial for minimising accidents and preventing damage to materials. Darko *et al.* (2017) stress that adequately trained workers are better equipped to handle materials safely and effectively. Adhering to quality standards is equally important, as it reduces the likelihood of rework, thereby cutting down on waste (Sev, 2009). Furthermore, effective on-site organisation and storage of resources prevent material degradation and loss, supporting overall waste reduction efforts (Abubakar *et al.,* 2022). Reusing materials whenever feasible is another critical element of sustainable handling practices. As Aboginije (2020) points out, material reuse not only curtails waste but also results in cost savings. Materials such as concrete and steel can be incorporated into recycling initiatives, repurposed for future projects, and kept out of landfills (Njoku & Edokpayi, 2023). Employing proper handling techniques ensures that materials are stored, transported, and used in ways that minimise damage and waste (Njoku & Edokpayi, 2023). Detailed waste tracking and record-keeping are integral to improving waste management. These systems provide essential data on waste production trends, enabling contractors to identify inefficiencies and refine their strategies (Lu *et al.,* 2017). Such tracking optimises handling practices and ensures alignment with sustainability goals. Continuous training in material handling practices is vital for maintaining high standards and addressing new challenges. Regular training reinforces accountability and ensures workers follow best practices in waste management (Abarca-Guerrero *et al.,* 2017). Separating materials at the point of collection simplifies recycling efforts and enhances overall waste management efficiency, contributing to the sustainability of construction projects (Ng *et al.,* 2018).

2.8.5 Culture

Building a robust organisational culture is critical for successful construction waste management as it fosters shared responsibility and sustainable practices. To ensure collaboration and transparency, teams must maintain effective communication. Onamade *et al.* (2022) highlight that clear and open communication channels facilitate the exchange of ideas and constructive feedback, ultimately improving decision-making and problem-solving processes. Encouraging input from all team members promotes inclusivity and teamwork, strengthening their commitment to waste reduction initiatives. Additionally, integrating sustainability into the organizational culture requires ongoing training and skill development. Regular training programmes provide employees with the skills and knowledge necessary to implement efficient waste management strategies and adopt innovative approaches (Hasmori *et al.,* 2020). Keeping employees informed through ongoing education ensures they stay updated on the latest advancements and best practices in waste management. Enforcing strict policies against negligence and unsafe practices strengthens accountability within the organisation. Osmani *et al.* (2008) highlight that clear and well-communicated waste policies establish precise expectations for all staff, clarifying their roles and responsibilities. A zero-tolerance approach to waste management ensures employees prioritise sustainability standards. Similarly, implementing policies against unsafe practices promotes a safe working environment, reducing material waste caused by mishandling (Nzima & Ayesu-Koranteng, 2021). Cultivating an environment where employees take pride in their contributions is equally important. Workers who feel a sense of achievement are more likely to engage in high-quality, waste-conscious activities (Onamade *et al.,* 2022). Celebrating their successes fosters a positive work culture, further motivating them to participate in sustainable practices. Incentivising sustainability efforts through rewards can further encourage waste reduction. Nzima and Ayesu-Koranteng (2021) note that recognition schemes, bonuses, and awards motivate employees to adopt eco-friendly behaviours and pursue continual improvement. Yang *et al.* (2020) add that such incentives create a cycle of positive reinforcement, driving employees to sustain and expand their waste management efforts. Active involvement from senior management is crucial for embedding sustainability within the organisational culture. Senior leaders serve as change agents by endorsing waste management initiatives and allocating the necessary resources. Their visible commitment to sustainability sets an organisational standard, ensuring waste reduction remains a central focus (Hasmori *et al.,* 2020).

2.8.6 Lean construction principles

Lean construction principles involve eliminating waste through a continuous improvement process, such as minimising material waste and reducing rework (Howell & Koskela, 2000). The basic principles of Lean Construction include planning carefully to reduce waste, increasing communication between team members as well as the construction company and the client, ensuring that client needs are met with zero delays and discrepancies and using data to establish a predictable workflow (Lu *et al*., 2017). Hence, Mbadugha *et al*. (2021) argue that for contractors to address issues related to waste reduction, contractors should promote the adoption of lean construction.

2.8.7 Building information modelling (BIM)

Building Information Modelling (BIM) plays a major role in construction waste management and reduction because it improves many areas of the construction process (Jamil & Fathi, 2018). According to Onamade *et al*. (2022), BIM facilitates detailed 3D models that reduce construction errors and alterations, which are significant sources of waste, by enabling precise planning and design. Mbadugha *et al*. (2021) claim that BIM's clash detection tools help to minimise on-site adjustments and related waste by identifying possible conflicts between building systems. Moreover, Lu *et al*. (2017) argue that BIM helps with accurate material quantification, which minimises overordering and excess materials, which frequently lead to waste. Additionally, Mbote and Makworo (2018) noted that by applying just-in-time procurement, this precise data reduces the possibility of material deterioration or damage from extended on-site storage. The capacity of BIM to model construction processes aids in determining the optimal order of operations, cutting down on pointless tasks and downtime, both of which contribute to a reduction in waste production (Killingsworth *et al*., 2020).

2.8.8 Green building practices

Green building is the process of designing and constructing buildings while employing methods that are resource and environmentally conscious at every stage of a building's life cycle, from siting, design, construction, operation, maintenance, renovation, and deconstruction (Liu *et al*., 2020). According to Lu *et al*. (2017), green building practices involve designing buildings that minimise waste generation, promote material reuse, and conserve energy and water. Aboginije *et al*. (2020) state that green building techniques are becoming more and more popular in the construction industry as builders look to lessen their carbon footprint.

2.8.9 The influence of project drawings/designs

Project designs provide a visual representation of the architect's or engineer's concept and form the basis for the planning and execution of the construction project. They are crucial for precise cost projections and material procurement, assisting contractors in locating and utilising the appropriate materials (Darko *et al*., 2017). Mbadugha *et al*. (2021) added that it is essential for contractors to minimise these risks by sticking to the original plans because deviating from the design standards can result in hazards and legal obligations. According to Onamade *et al*. (2022), effective communication and collaboration between project stakeholders are crucial to guarantee that the finished product meets the client's expectations and the design intent. In some instances, contractors may work with architects and engineers to suggest design changes that improve efficiency, sustainability, or cost effectiveness during construction (Darko *et al*., 2017). As per Jamil and Fathi (2018), construction projects can be more productive overall by utilising integrated design processes, 3D (Three-Dimensional) modelling, and Building Information Modelling (BIM) tools to optimise material consumption, eliminate waste, and increase overall efficiency. Furthermore, Killingsworth *et al*. (2020) add that BIM improves the efficiency of construction sites by facilitating the visualisation of detailed designs and the detection of clashes during the planning stage, which minimizes errors and rework on-site.

2.8.10 Precise material estimate

The waste of construction materials is thought to range from 10 to 30 percent because of loss, damage, and over-ordering (Tafesse *et al*., 2022). Mbadugha *et al*. (2021) reveal that the construction manager should use extreme caution to prevent overordering because it results in an untidy construction site and could result in material loss. Saidu and Shakantu (2016) argue that overordering raises costs for the builder because the delivery and disposal of these goods come at a specific price. Although some materials like plasterboard linings, cladding trims, faced or rubbed stones, insulation materials, and other items need to be overordered to avoid problems at a later stage (Saidu & Shakantu, 2016), the material that is left due to over estimation can be used on another project. According to Babatunde *et al*. (2019), construction management software can be utilised to coordinate suppliers and subcontractors and schedule the need for specific materials. The biggest waste generators can be found and addressed by looking back at the resources used in the previous project to avoid repeating the same mistakes.

2.8.11 Effective planning

A construction waste management plan is a document that describes the management, disposal, or recycling of construction waste (Hung & Kamaludin, 2017). The waste management plan is updated during the construction phase to demonstrate that any materials that cannot be recycled or otherwise used are disposed of at a permitted disposal site (Nagapan *et al.,* 2012). The waste management plan should consider the kind and volume of construction waste as well as the facilities and resources that are available, according to Crawford *et al.* (2017). Abubakar *et al*. (2022) identify the primary objective construction waste management plan as to reduce the number of materials dumped in landfills during construction by preventing construction waste, demolition waste, and land clearing debris from being disposed of. Romero-Hernandez and Romero (2018) add that a waste management plan also helps redirect recyclable recovered material back to the manufacturing process and redirect reusable materials to appropriate sites. It minimises the environmental impact of construction waste (Galvez-Martos *et al*., 2018). As per Udawattaa *et al*. (2015), the principal contractor is typically in charge of developing the waste management plan for each project, and from this plan, requirements can be created for bid/contractor packages defining processes for salvage, reuse, and recycling. The three pillars of sustainability (i.e., the economic, social, and environmental elements) are enhanced by the implementation of the construction waste management strategy (Zaman *et al*., 2020). In addition to the cost savings it provides contractors, there are additional advantages for the public, authorities, and the environment in the form of reduced waste accumulation-related social problems, enhanced public health, and resource efficiency (Nagapan *et al.,* 2012).

2.8.12 Effective training regarding site waste management

Construction waste management in numerous nations has been recognised as being improved by training and education, which give contractors, designers, and customers the ability to boost staff knowledge, attitudes, and awareness of waste management (Hung & Kamaludin, 2017). The construction waste can be minimised through proper awareness among workers and the profit margin will increase significantly (Saadi *et al*., 2016). Nyika *et al*. (2019) advised that all construction workers should undergo proper training and orientation on construction waste management practices. This will ensure that they are aware of the proper handling and disposal of construction waste. Additionally, the manager of the construction site needs to interact with the local waste management authorities. This ensures that the construction site adheres to all rules and laws regarding the management of construction waste. Moreover, to raise public awareness and engagement in oversight, governments need to launch informational campaigns or use social media to highlight the advantages of construction waste management (Abubakar *et al*., 2022).

2.8.13 Prefabrication

According to Mbadugha *et al*. (2021), prefabrication is the process of manufacturing a full structure or assembling its parts at a facility offsite and assembling them on site from self-sufficient volumetric modules or independent panels. According to Wang *et al*. (2020), prefabrication has less of an impact on the environment because materials are recyclable. Killingsworth *et al*. (2020) identify prefabrication, modularisation, and off-site construction methods as excellent ways to design out waste, therefore choosing them as an alternative to traditional construction methods which can help to reduce waste. Additionally, Nyika *et al*. (2019) noted that off-site production provides a greater chance for the management of the materials before they leave the factory and a far more effective way to lessen the quantity of waste that is dumped in landfills. Ng *et al*. (2018) observed that appropriate training and education are required to change attitudes within the construction industry about the implementation of prefabrication as a waste minimisation strategy.

2.8.14 Zero waste management practices

There is pressure to effectively recover and reuse materials due to the rising demand for earth resources across all sectors (Balaram, 2019). In this regard, waste management has emerged as a crucial requirement for efficient utilisation (Song *et al*., 2017). The "zero waste" idea which is a perceptive system of waste management has been introduced as an alternative solution for waste problems globally in recent years (Coskun, 2022). According to Yu *et al.* (2021), the zero-waste idea encourages resource-efficient consumption and production, maximises resource recovery and recycling, and prevents waste from being disposed of in landfills and incinerators. The zero-waste strategy is a valuable framework that requires consistent focused effort (Coskun, 2022). Awareness and transformative knowledge about the choice of an environmentally friendly lifestyle are often believed to motivate behaviour change (Zhao, 2021). Zaman and Lehmann (2011) proposed that a zero-waste city should recover 100% of its resources from waste and should achieve a 100% recycling rate. South Africa has set a high target of having no waste in landfills by the year 2030 (Mbazima *et al*., 2022).

The construction industry has identified material waste as a significant issue with significant consequences for both the efficiency sector and the environmental effect of construction projects (Ismaeel & Kassim, 2023). Since waste measurement is a useful tool for evaluating the effectiveness of production systems and highlighting areas for future improvement, it is crucial to their management (Hasmori *et al*., 2020). According to Muhwezi *et al*. (2012) construction material can make up as much as half of a project's overall cost. The efficiency with which a materials purchase is managed is a key factor in determining a project's success and profitability. Muhwezi *et al*. (2012) noted that it is crucial to address any actions that can result in the improper materials being purchased before placing a materials order.

In a material estimate, the idea of "zero waste allowance" relates to the idea of avoiding or eliminating waste during a manufacturing or construction process (Hasmori *et al*., 2020). Darko *et al*. (2017) state that planning and measurement are required to guarantee that the necessary materials are used effectively and that there is little to no excess material left over as waste. According to Yu *et al*. (2021), for a construction project with a zero-waste allowance, estimators must be as accurate as possible by using the project requirements and design plans. Zaman and Lehmann (2011) provided that the traditional material estimates frequently contain a margin for overages to accommodate for waste, errors, or unforeseen conditions. A zero-waste allowance strategy aims to reduce these overages, resulting in more effective resource usage (Zaman & Lehmann, 2011). However, Coskun (2022) noted that following a zero-waste allowance estimate helps contractors place orders for materials more accurately, ensuring they get what they need. Implementing a zero-waste allowance in material estimating promotes responsibility throughout the building process (Stubbs, 2021). This method saves money and the environment since it eliminates the need to dispose of waste materials and reduces project costs overall (Ajayi & Oyedele, 2018).

2.9 The coordinated effort needed across stakeholders

Stakeholders are categorised into external and internal stakeholders. External stakeholders include governments, the public, and experts such as academics and researchers, while internal stakeholders are direct participants of construction projects and waste recycling, including clients, designers, contractors, subcontractors, and waste recycling companies (Zhao, 2021). The environment is significantly impacted by waste produced by the construction industry. Consequently, construction waste management must be implemented, which calls for stakeholders' participation (Zhao, 2021). The goal of the South African government is to create, implement, and maintain an integrated pollution and waste management system that supports sustainable growth and measurable quality of life improvements by mobilising the passion and commitment of all South Africans for the efficient prevention, minimisation, and control of pollution and waste (DEA, 2018). Esa *et al*. (2017) state that to minimize waste generation throughout the construction cycle, managing waste production must start during the planning and designing stages. Additionally, it is anticipated that education and continued professional development programmes will help designers and architects to acquire a favourable understanding of and attitude toward the management of construction waste (Zhao, 2021).

2.10 Proposed framework for construction waste reduction in South Africa

The study's goal is to create an effective framework for construction waste reduction based on the results of this study, which centre on perceptions, drivers, challenges, and practices related to waste management. To create interventions that appeal to industry stakeholders, it is essential to comprehend contractors' perspectives on construction waste management. Contractors frequently put operational success and cost effectiveness ahead of sustainability, which emphasizes the need for training and awareness programs that highlight the long-term advantages of waste reduction (Ajayi *et al*., 2017). A culture of accountability and resource optimization can be promoted, and contractors' perceptions can be changed by educating them about the financial and environmental effects of waste (Hasmori *et al.,* 2020). The key drivers behind contractors' waste management practices, such as regulatory compliance, client demands, and cost-saving potential, form the foundation for creating an effective mechanism. According to Nzima and Ayesu-Koranteng (2021), contractors may be persuaded to embrace waste reduction measures by offering incentives such as tax rebates or lower landfill fees for using sustainable practices. The feasibility of putting waste management strategies into action can also be enhanced by stakeholder collaboration, such as alliances with recycling facilities and local government (Gálvez-Martos *et al.,* 2018). Addressing the challenges contractors face in reducing construction waste is essential. Problems such as insufficient on-site sorting facilities, limited access to recycling centres, and inadequate training can be addressed with targeted solutions. For example, adopting modular construction techniques and promoting the reuse of materials like steel and concrete can help reduce waste at its source (Aboginije, 2020). Offering technical support and capacity-building programmes can assist contractors in overcoming obstacles to sustainable practices (Lu *et al.,* 2017). The proposed mechanism should centre around effective construction practices adopted by contractors, including material optimisation, just-in-time delivery, and source separation. Integrating technologies such as Building Information Modelling (BIM) can improve material tracking and reduce waste during project execution (Ajayi *et al.,* 2017). Regular waste audits and thorough record-keeping will also enable contractors to track waste trends and adjust their practices accordingly (Spišáková *et al.,* 2021).

2.13 Chapter conclusion

The current studies confirm the necessity for the construction industry to concentrate on the prevention of construction waste to reach a considerably higher level of performance, even though such a concentration has long been thought to be impractical. The studies suggest that construction waste may be greatly decreased by using standard material sizes and modern construction techniques, which would reduce waste from breakage, residual materials, and other key causes of waste. The idea for the industry to switch from the lower level of waste prevention to the current construction waste reduction approach needs to be explored within a formal framework to be analysed appropriately. Such an attempt would focus on waste prevention and increase the effectiveness of procedures during the project design phase. Waste avoidance is one of the all-encompassing strategies to encourage construction techniques and practitioners to focus more on a zero-waste approach. Although there may be a one-time expense, it has long-term benefits such as enhanced construction techniques, more resource efficiency, and increased environmental sustainability.

CHAPTER THREE
METHODOLOGY AND DESIGN

3.1 Introduction

Chapter two which is literature review gives a summary of the state of knowledge regarding the handling of construction waste. The researcher developed an effective framework to cut down on construction waste by using a quantitative approach with a particular target group of contractors. The purpose of this study is to provide answers to the research questions, and the only way to do this is by using a suitable research methodology. This chapter starts with an overview of the available research methodologies, and then it goes on to discuss the research design that was employed for this study. The research problem, questions, and objectives are carefully evaluated to guide the selection of the most suitable research methodology.

3.2 Research philosophy

Research philosophy refers to the framework used to understand the development and nature of specialised knowledge (Pawlikowski *et al.,* 2018). It provides a philosophical foundation that guides and supports the conclusions drawn from a study (Tamminen & Poucher, 2020). According to Ryan (2018), research philosophy is concerned with the nature and progression of knowledge. Pawlikowski *et al.* (2018) identify positivism and interpretivism as the two primary philosophical frameworks for research.

3.2.1 Positivism

Positivism links research efforts to quantitative methodologies (Tamminen & Poucher, 2020). Its defining feature is its alignment with the perspective of natural science, focusing on observable social realities and enabling the creation of generalisations akin to scientific laws (Park *et al.,* 2020). According to Pawlikowski *et al.* (2018), positivist studies often involve testing theories or hypotheses, aiming to identify broad patterns through an objective view of reality. This study adopts a positivist approach to explore waste management practices implemented by contractors.

3.2.2 Interpretivism

The interpretivist research paradigm seeks to develop theoretical insights by adhering to scientific principles (Alharahsheh *et al.,* 2020). Interpretivist designs aim to provide subjective explanations of phenomena based on the perspectives of participants involved (Tamminen & Poucher, 2020).

Moreover, interpretivist studies are often used to develop new theories (Ryan, 2018). Alharahsheh et al. (2020) outline four foundational assumptions underlying the interpretivist philosophy as:

- It takes a critical approach toward undiscovered, secret knowledge and examines it.
- To fulfil the study's goals, qualitative methodologies are used, as well as social interactions with participants.
- Social processes and behaviours, as well as subjective knowledge, are relative.
- The languages utilised for data interpretation come from social interactions with individuals at a specific location and time.

Due to the study's emphasis on numerical data and statistical analysis, for this study, a quantitative approach was chosen. The emphasis on subjective interpretations and qualitative data in the interpretivist paradigm did not fit with the research's need for exact, measurable results.

3.3 Research approach

The phrase "research approach" describes the procedures for collecting and analysing data as well as the general structure of a research process regarding the kinds of information that must be obtained and the interpretations that must be made of them in order to successfully answer a research question (Bhattacherjee, 2012). The type of research approach can help determine whether research options and strategies will be successful or unsuccessful in each study (Saunders *et al*., 2011). According to Saunders *et al*. (2011), there are two types of research methods: deductive and inductive. When a theory or hypothesis is tested, a deductive technique is used. On the other hand, an inductive strategy involves the analysis of gathered facts and the subsequent development of a theory. Although such categorisation is of no real practical value, deduction is more connected with positivism and induction with interpretivism philosophy (Bhattacherjee, 2012).

3.3.1 Deductive approach

The purpose of deductive research is to test concepts and established patterns from theory using new empirical data (Walliman & Walliman, 2005). The main feature of a deductive approach seeks to explain the causal connections between variables. To adequately test a theory or a hypothesis, the technique requires control of the variables that are being studied. It works well with structured data gathering tools (Saunders *et al*., 2011). Deduction requires that the researcher be independent of the object of observation or the subject of the study to respect the criteria of scientific rigour. Furthermore, Saunders *et al*. (2011) pointed out that another crucial aspect of deduction is the requirement for ideas to be clarified and made simpler in a way that makes it possible to quantify facts. Furthermore, it is mentioned that samples in a deductive approach need to be sufficiently large to permit statistical generalizations about the correlations between the variables. With reference to the deductive approach, an efficient framework for lowering construction waste in South Africa was developed using the quantitative method. In this research study, a deductive approach was chosen because it allows for quick and simple conclusion-making without requiring extensive research or experimentation (Walliman & Wallilman, 2005). In deductive strategy, conclusions are derived from premises using valid logical principles. It involves moving from general principles or assumptions to specific conclusions or predictions (Saunders *et al*., 2011).

3.3.2 Inductive approach

According to Saunders *et al*. (2011), the inductive method allows theory to come after data; a smaller sample size may be more suited for inductive approaches. Additionally, it is noted that an inductive approach's alignment with the use of qualitative data and flexibility to employ a range of data collection techniques to build various points of view on the study's subject are other elements of the approach (Azungah, 2018). The choice of an approach is particularly crucial in research since it encourages a better-informed choice of study design. Bhattacherjee (2012) claims that the purpose of inductive research is to infer or identify theoretical concepts and patterns from observed data. This study focus was on numerical data analysis because it used a quantitative methodology. Inductive approaches, which frequently involve formulating theories or hypotheses based on qualitative observations, did not align with the quantitative focus of the study.

3.4 Research strategies

The research strategies that will be used must be identified in the research design. Each of the approaches can be used for exploratory, descriptive, or explanatory research. Descriptive studies aim to accurately reflect events or situations, whereas exploratory investigations strive to comprehend what is happening to develop new insights. Explanatory investigations establish the causal connections between the variables (Saunders *et al*., 2011). This study is more descriptive in nature. According to Saunders *et al*. (2011), some research methodologies fall under the deductive approach while others go under the inductive approach. Therefore, the most crucial factor is whether the method is suitable for addressing a certain research topic and achieving the research's goals. There are several methods for conducting research, including ethnography, grounded theory, action research, surveys, and experimental studies. For this study, it is preferred to use a survey approach, as explained and justified below.

3.4.1 Survey

Survey is the process of gathering data via questionnaires that ask many people a lot of questions (Pallant, 2020). A small sample population can be studied at one moment in time using questionnaires in a variety of contexts. However, surveys can be carried out by phone, post, email, website, or face to face. This makes this strategy very flexible and easy to use. Saunders *et al*. (2011) claim that surveys are the most often utilised research method for addressing "who, what, where, how much, and how many" research questions. A survey strategy's popularity stems from its inherent flexibility in collecting significant amounts of data in a highly efficient manner. However, a notable drawback of this approach is that, because the questions on the data collection instrument are the basis for the data collection, the data could not be as broad in scope as that obtained by other approaches. By including open-ended questions in the survey, this has been somewhat solved. This study used a survey with a questionnaire. Due to their capacity to effectively collect standardised, quantitative data from a broad and possibly sizeable pool of respondents, surveys using questionnaires are a highly suited form of data collection. This technique is particularly useful in a wide range of research contexts since it guarantees data consistency, permits anonymity, and is both cost- and time-effective.

3.5 Research choice

Research methodology is the methodical process of addressing a research problem by gathering data via a range of techniques, providing an analysis of the data, and deriving conclusions based on the results of the study (Creswell, 2007). According to Fapohunda (2014), research methodology is the process of weighing the benefits and drawbacks of the various research methodologies that are accessible to choose which approach is best for the study. Additionally, Leedy and Ormrod (2010) elaborate on this by proposing that the following are among the most important roles of research methodology:

- Establishing criteria for data collection; and
- Gathering information and offering analyses.

To get comprehensive answers to the research issues, research is a cyclic process that entails several careful and methodical steps. Biggam (2011) underscores the importance of the interrelationships among research methodologies, data collection strategies, and data analysis tactics. The author also states that to achieve research objectives, a researcher needs to be knowledgeable about the following fundamentals:

- Figuring out what data needs to be gathered.
- Acknowledging the importance of the data acquired.
- Determining the population's geographic location to gather data.
- Determining the duration of data collection.
- Selecting the method of data collection.

The Mono approach was used in this study, which entails utilising a single data collection technique. According to Saunders *et al*. (2011), when the researcher wants to collect data with depth rather than breadth, this method works well. The Mono approach guarantees consistency and depth in the data gathered by enabling a concentrated and thorough investigation of the research question (Denscombe, 2008).

3.5.1 Qualitative method

Creswell (2007) defines qualitative research as an understanding analysis grounded in methodological traditions that explore social or human experiences. Qualitative research attempts to comprehend the logic or interpret ordinary phenomena in terms of their significance by studying them in their natural environment. The qualitative research demands deliberate planning before beginning, mental focus and attentiveness throughout data collection, progressive data management abilities, and text-driven creativity during analysis and write-up (Creswell *et al*., 2011). The following circumstances lead to the selection of a qualitative study as the research approach (Creswell, 2007):

- Need for a detailed and complex understanding of the issue.
- The matter or subject that requires investigation.
- To comprehend the environment or framework in which study participants deal with challenges and problems.
- The requirement to give people the confidence to speak out, share their experiences, and lessen the close relationship that exists between the study's respondents and the researcher.
- The study problem is just not well-suited for quantitative research methods and statistical analysis; qualitative methods are more appropriate.

Due to the study's objectives and the necessity of quantitative data for achieving those objectives, the author decided not to use qualitative research methodologies in this study.

3.5.2 Quantitative method

Creswell (2007) emphasise that the goal of quantitative research is to collect numerical data and examine connections between theories, facts, and prior research to anticipate, explain, and control events. Similarly, Leedy and Ormrod (2010) contend that because quantitative research allows for the measurement of quantities and the examination of correlations between qualities, it is especially useful for answering issues pertaining to variables. A carefully considered plan is the first step in the methodical process of quantitative research, which next collects and analyses data to provide unbiased and trustworthy findings. This study uses a quantitative research methodology to accomplish its goals of examining South African contractors' perceptions, drivers, challenges, and practices surrounding construction waste management. This study is suited for quantitative research since it makes it possible to measure variables objectively and examine the connections between them, producing trustworthy and broadly applicable results (Nardi, 2018).

The use of this approach aligns directly with the research problem by enabling the study to examine the perceptions of contractors, identify key drivers for waste management practices, analyse the challenges hindering effective waste management, evaluate current waste reduction practices, and propose effective framework for construction waste reduction. By quantifying relationships between variables, such as contractors' perceptions and their adoption of waste reduction practices, the research design addresses the fundamental questions of how perceptions, drivers, and challenges influence waste management in the SACI. Survey questionnaires were selected as the primary data collection method because they are well-suited for gathering standardised data from a broad sample of contractors, ensuring the findings are generalisable (Kumar, 2016). Furthermore, this quantitative design facilitates statistical analysis, including descriptive statistics, factor analysis, and correlation analysis, to rigorously assess the relationships between the study variables.

3.5.3 Mixed method

As per Creswell *et al.* (2011), the mixed research method refers to a category of studies where the investigator integrates quantitative and qualitative research techniques, methodologies, approaches, or concepts, or any set of similar studies. Quantitative and qualitative research methods are combined into a single research form by the mixed method, according to Creswell and Clark (2011). Because several study philosophies are investigated for data collection, the mixed method is also known as a triangulation approach. A combination of approaches can help a study focus more broadly and capture elements of a phenomenon that are unique to a given methodology (Creswell, 2007). Mengshoel (2012) argue that approaches that are both qualitative and quantitative should be seen as complementary, not competitor. According to Suresh and Chandrashekara (2012), combining the qualitative and quantitative paradigms for triangulation or cross-examination in a research project is not a practical solution because the two paradigms do not investigate the same phenomenon. According to Creswell (2007), the qualities of mixed methods include the ability to address questions that pertain to both qualitative and quantitative approaches, offering researchers a comprehensive and detailed perspective in their studies, and encouraging the adoption of diverse paradigms related to these methods. Furthermore, Creswell and Garrett (2008) highlight several challenges associated with using mixed methods, such as the unusual combination of data (e.g., structural equation modelling and discourse analysis), selecting qualitative follow-up respondents from qualitative data, and avoiding inconsistencies when integrating quantitative and qualitative methodologies. Furthermore, mixed methods need to manage the tension between methodological and philosophical contexts, as well as negotiate important decisions and carefully assemble the research team.

Due to several important factors that include budget constraints and time availability, the researcher decided against using a mixed methods approach in this research. The primary focus of this study topic was on quantifiable information and specified factors, which made a quantitative approach more appropriate. Mixed methods would have been more complex and might have taken resources away from the primary goals if the qualitative component, which entails in-depth background and inquiry, had been included.

3.6 Data collection techniques and procedures

Omran *et al*. (2011) assert that the data collecting phase is essential to fulfilling study goals since it entails compiling all necessary data from significant sources. Both primary and secondary sources of data were employed to get the information for this investigation. Well-structured questionnaires, which are often utilised in quantitative research, were employed to collect the data for this study (Aboginije *et al*., 2020). However, secondary data were gained by using recent literature published in books, journals, and conferences including government reports. According to Kumar (2016), reading literature broadens a researcher's knowledge base and aids in integrating conclusions or discoveries with the body of current knowledge. The level of agreement for respondents was indicated using the following Likert scale: Strongly Disagree = (1), Disagree = (2), Moderate = (3), Agree = (4), Strongly Agree = (5) and Unsure= (U) for the following objectives: the perception of contractors regarding construction waste management**,** key drivers for contractors’ waste management practices, and challenges experienced by contractors related to reduction of construction waste. Construction waste management practices were rated using the following Likert scale: To a very small extent =1, Small extent =2, Moderate extent =3, Large extent-= 4. Extremely large extent = 5 and Unsure= U.

3.6.1 Primary and secondary sources of data.

Primary data refers to information gathered directly from sources using a questionnaire (Ajayi, 2017). Fife-Schaw (2020) noted that it is possible to manage questionnaires through the mail and ask respondents to mail them back or can be distributed and a sample of respondents asked to complete the survey. A secondary source is one that was produced afterwards by an individual who was not present at the events the author is writing about or who did not have firsthand knowledge of them (Coghlan, 2019). According to Ajayi (2017), secondary sources include books, conference papers, theses, and the internet. The library of the Cape Peninsula University of Technology (CPUT) was the site of the information search.

3.6.2 Sample

The sampling design for this study focused on selecting contractors operating within the Eastern Cape province of South Africa, specifically those registered under the construction industry development board (cidb) Grades 5 to 9. Waste management procedures are crucial in building projects of all sizes and complexity, which is why these contractors were singled out. Professionals including quantity surveyors, construction managers, site agents, health and safety (H&S) managers, and site technicians were among the responders. These positions were specifically chosen because the experts have the knowledge, experience, and power to make decisions required to respond intelligently to questions about waste management procedures and issues in the SACI. The study used a non-probability purposive sampling technique, which was chosen because it was good at choosing respondents according to certain standards that matched the goals of the research. This strategy made guaranteed that only professionals and contractors actively involved in construction waste management were included, which increased the data's accuracy and usefulness. Elements of random sampling were also included to improve representativeness and lessen selection bias. Random sampling enhanced the robustness of the study by providing every eligible member of the designated population with an equal chance of being chosen, if they fulfilled the inclusion requirements. This combination of purposive and random sampling ensures a focused yet balanced dataset.

This sampling approach aligns with the research problem by targeting stakeholders who directly influence or are impacted by construction waste management. The selection of contractors was based on their direct respondents in addressing sustainability issues and putting waste management procedures into action. While H&S managers and site technicians supplied crucial viewpoints on compliance, safety, and on-site waste management procedures, quantity surveyors and construction managers provided insightful information about the operational and financial aspects of waste management. By focusing on these stakeholders, the sampling design ensures the study gathers relevant data to address its objectives of assessing construction waste management practices, challenges, and framework for improvement.

The sampling framework was based on a population defined as all contractors registered on the cidb database within the Eastern Cape province in Grades 5 to 9. These grades reflect contractors' operational capacity and project scale, making them representative of the study's scope. A total of 228 contractors were identified, including 53 from Grade 5, 83 from Grade 6, 60 from Grade 7, 28 from Grade 8, and 4 from Grade 9. The study utilised the formula developed by Krejcie and Morgan (1970), as cited in Mahmood and Othman (2020), to calculate an appropriate representative sample size. The formula is expressed as s = d2 (N-1) + x2 P (1-P) / x2NP (1-P).

where s = the necessary sample size.
X2 = the chi-square table value for one degree of freedom at the chosen level of confidence.
N = the size of the population.
P = the proportion of the population.
d = the accuracy level given as a percentage.

To achieve a sample size with a given degree of accuracy, a population size of 228 and a population proportion of 50% were assumed (Suresh & Chandrashekara, 2012). As in other studies, a 95% confidence level was assumed, with the degree of accuracy expressed as a proportion of 0.05 and z = 1.96 at the 95% confidence level. Therefore, the minimum sample selected for the study is 144.

s = x2NP (1-P) / d2 (N-1) + x2 P (1-P)

s= (1.96) ^2 .228.0.5(1-0.5)/ (0.05) ^2(228-1) +(1.96) ^2.0.5(1-0.5)

s=143.3

s=144

Contractors were chosen from the cidb database and invited to participate via email as part of the sample procedure. To ensure they fulfilled the requirements for inclusion namely, active participation in waste management procedures on construction projects were examined. This approach made sure that information was obtained from knowledgeable and pertinent experts, successfully tackling the goals and challenges of the study.

3.6.3 Population

The study focused on contractors operating in South Africa's Eastern Cape province, registered under cidb Grades 5 to 9. These contractors were chosen due to their involvement in diverse construction projects where effective waste management is essential. The research targeted specific industry professionals, including quantity surveyors, construction managers, site agents, H&S managers, and site technicians, identified for their expertise and experience in construction waste management practices and challenges.

Data collection was carried out using a well-structured questionnaire distributed to the identified population. To ensure ethical integrity and credibility, all responses were kept anonymous, with measures in place to protect the identities and confidentiality of respondents. Data analysis relied on averaged statistics across the population, ensuring no individuals or groups could be identified in the study’s findings. This selected population aligns with the study's objective of developing an effective framework for construction waste reduction, as these professionals are directly involved in relevant decision-making and operational activities.

3.6.4 Questionnaires

A questionnaire is a set of questions intended to methodically record respondents' responses, originally developed by Sir Francis Galton as a research instrument. According to Bhattacherjee (2012), there are two types of questionnaires: structured, which provide predetermined answer choices, and unstructured, which provide open-ended answers. To simplify analysis and improve replicability, a structured questionnaire was selected for this study to enable uniform, effective, and comparable data collecting. This choice is consistent with the quantitative research methodology, which allows for the methodical assessment of contractors' perception, drivers, challenges, and practices concerning the management of construction waste in South Africa.

The design of a questionnaire has a major impact on response rates, validity, and reliability (Saunders et al., 2011). This study used a well-designed questionnaire with direct, succinct, and understandable questions to guarantee high-quality replies. To encourage uniformity and clarity, structured questions were employed, which assisted respondents in offering pertinent insights into the research problem. Pallant (2020) noted that the instrument's applicability and compatibility with the study's framework determine the quality of the data. As a result, the questionnaire was designed to precisely meet the goals of the study, guaranteeing consistency with the research topic and associated variables. The questionnaire is divided into five sections, each of which is designed to address a certain study goal. Section A collects demographic information to contextualise responses. Section B addresses the first objective, focusing on contractors' perceptions of construction waste management. Section C aligns with the second objective by exploring key drivers of contractors’ waste management practices. Section D pertains to the third objective, identifying challenges in reducing construction waste. Finally, Section E addresses the fourth objective by investigating construction waste management practices adopted in South Africa. This structured format ensures comprehensive coverage of the research objectives and facilitates detailed analysis. To optimise response rates and data quality, the questionnaire was distributed via email, allowing respondents to complete it at their convenience online. Its design included a clear explanation of its purpose and an engaging, visually appealing format to encourage participation. These considerations ensured that the questionnaire effectively captured reliable and valid data to address the study's research problem and objectives.

3.6.5 Data analysis

SPSS version 26 was utilized for data analysis in this study, which made it easier to create graphs, pie charts, and tables that effectively displayed the results. The demographic profiles and attitudes of the respondents about construction waste management were summarized using descriptive statistics including means, standard deviations, frequencies, and percentages. Advanced statistical methods were also used to achieve the study's goals. The study employed Factor Analysis (FA) to identify underlying variables, with a specific focus on management attitudes on construction waste management and the driver’s contractors have in cutting waste. Using Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy, the dataset's appropriateness for FA was evaluated. The components were given meaningful names, and interpretation was made simpler by using the Varimax rotation approach, which also kept factors with eigenvalues greater than 1. FA proved appropriate for this study as it enabled the identification of latent variables and grouped related factors, providing deeper insights into contractors' perceptions and challenges in waste management, directly supporting the study’s objectives.

The Relative Importance Index (RII), which was derived from Likert-scale questionnaire responses, was used to rank and prioritize the major factors impacting contractors' waste management practices. Higher scores indicate greater importance. The RII awarded values between 0.00 and 1.00. This method offered a quantitative approach to evaluating the significance of various factors, supporting the objective of identifying the most influential drivers of waste management practices. Additionally, an Analysis of Variance (ANOVA) test was conducted to compare perceptions of cost concerns across different demographic groups. ANOVA identified statistically significant differences in group means, providing insights into how demographic factors influence contractors' attitudes toward waste management. This approach was suitable as it allowed for the comparison of means across multiple groups, addressing the objective of analysing demographic-based variations in perceptions. Reliability was measured using the Cronbach's Alpha coefficient, which assessed the internal consistency of Likert-scale items. Reliability scores were interpreted on a scale, with $\alpha \geq 0.9$ indicating high reliability and $\alpha < 0.5$ reflecting inadequate reliability. A pilot test ensured the instrument's reliability. The validity of the survey tool was confirmed through an extensive review by the study's supervisor and co-supervisor, who identified and addressed potential ambiguities and biases in the questionnaire. This process aligns with Robinson and Leonard's (2018) claim that resolving ambiguities in survey design enhances the accuracy and trustworthiness of data collection.

3.6.5.1 Descriptive Statistics

The primary characteristics of a set of data are quantitatively summarised and described using descriptive statistics (George & Mallery, 2018). Holcomb (2016) highlighted that descriptive statistics give a clear and succinct summary of the data at hand, while inferential statistics concentrate on making assumptions or predictions about the population from a sample. Central tendency measures (mean, median, mode, and most frequent value) are important parts of descriptive statistics because they show the usual value in a data collection (Kaur *et al*., 2018). Furthermore, Cooksey and Cooksey (2020) noted that data point dispersion and spread are described by variability measurements like variance, standard deviation, and range. The distribution, trends, and correlations of the data are frequently shown graphically using representations such as scatter plots, bar charts, histograms, and box plots (Cooksey & Cooksey, 2020). Descriptive statistics facilitate simpler interpretation and serve as a basis for additional statistical analysis by condensing vast volumes of data into comprehensible representations (Moore *et al*., 2012). The data in this study were analysed and presented using descriptive statistics, which allowed for a clear communication of the findings and guaranteed a thorough knowledge of the data set.

3.6.5.1.1 Mean score

In this study, mean score analysis was employed to evaluate and rank the perceptions of contractors regarding construction waste management, the challenges experienced by contractors in reducing construction waste, and construction waste management practices in South Africa. This method is particularly suited for analysing Likert-scale data, where respondents rated factors such as the importance of specific challenges on cost concerns, management attitudes towards construction waste management, lack of training to reinforce the importance of waste management practices as listed on the questionnaire survey that was distributed. The challenges include, lack of waste reduction goals, lack of comprehensive waste management plan, choosing material without thorough thinking**,** the effectiveness of various waste management practices on effective waste management on construction site, procurement, handling, operation, culture as per survey questions. The mean score for each factor was calculated by averaging responses, providing a summary measure that represents the collective perception of respondents. These mean scores were then ranked in descending order to identify the most critical and least critical factors based on their relative importance. For instance, factors with higher mean scores were interpreted as the most significant perceptions, challenges and effective practices, while those with lower mean scores were deemed less critical (Pallant, 2020). This analysis helps prioritise areas requiring intervention and aligns with the research objectives of assessing perceptions, challenges, and practices for effective construction waste management. By focusing on these ranked factors, the study provides actionable insights for enhancing waste reduction framework in South Africa (Field, 2018).

3.6.5.2 Factor analysis

Factor analysis is a statistical technique used to uncover the underlying structure within large datasets by identifying the relationships between latent components and observed variables (Pallant, 2020). Yong and Pearce (2013) explain that factor analysis can be performed using two main approaches: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). CFA assesses how well the data fits a pre-established hypothesis regarding the type and number of components, while EFA, being independent of any predetermined structure, identifies hidden factors within the data (Bandalos and Finney, 2018). In this study, EFA was employed to identify latent variables in a data-driven and assumption-free manner. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to assess the dataset's suitability for factor analysis. A KMO value exceeding 0.6 and a significant result from Bartlett's test indicates the data is appropriate for such analysis (Pallant, 2020; Alordiah & Chenube, 2023). These criteria were satisfied, validating the use of factor analysis for this study. The sample size adhered to Pallant (2020) guideline, requiring at least 5 to 10 respondents per variable to ensure robust and reliable results. The decision on the number of factors to retain was guided by the eigenvalue > 1 rule, a widely accepted criterion that considers factors with eigenvalues above 1 as significant contributor to the dataset's variance. This method ensured the retained factors were meaningful and provided a comprehensive understanding of the study's core concepts.

3.6.5.3 Relative importance index

Relative Importance Index (RII) is a statistical tool for evaluating and ranking the importance of variables according to respondents' opinions (Rooshdi *et al*., 2018). As per Rooshdi *et al*. (2018), this index is frequently used in a variety of disciplines, including marketing, construction management, and education to rate elements like project hazards, factors influencing student success in school, or customer preferences. Kazakis *et al*. (2015) defined RII as a numerical value that offers an indication of the relative significance of each element. This approach entails distributing a Likert-scale questionnaire to obtain evaluations, giving these ratings weights, and calculating the RII for every element to make ranking easier (Kazakis *et al*., 2015). According to the RII criterion, RII accepts values between 0.00 and 1.00; the higher the value, the more significant the item, and vice versa. Chen *et al*. (2020) have provided the following importance rating for the RII. The level of importance is established by the RII, which employs the ordinal scale technique, using the following ranking scales: 0.8 < RII < RII < 0.8 (High-Medium); 0.4 < RII < 0.6 (Medium); 0.2 < RII < 0.4 (Medium-Low); and 0.0 < RII < 0.2 (Low). This study used the RII technique for analysis and prioritisation to ensure a methodical and quantitative evaluation of the components under investigation's relative relevance.

3.6.5.4 ANOVA test

According to Mishra *et al*. (2019), an ANOVA test is a statistical technique that compares the means of three or more groups to ascertain whether the means of at least one group differs statistically from the others. According to Stoker *et al*. (2020), there are various forms of ANOVA, such as Repeated Measures ANOVA, which compares means when the same subjects are used for each treatment: One-Way ANOVA, which compares means based on one factor, and Two-Way ANOVA, which considers two factors and their interaction. Group means, mean squares, the F-ratio, the p-value, and the sum of squares within and between groups are all calculated as part of the process (Mishra *et al*., 2019). ANOVA requires several presumptions to be satisfied to be valid, including sample independence, normality of data distribution within each group, and variance homogeneity (Pituch & Stevens, 2015). Additionally, Stoker et al. (2020) stresses the importance of the p-value in interpreting the data because it rejects the null hypothesis that all group means are equal and indicates a significant difference between group means when it is less than the chosen significance threshold (e.g., 0.05). An ANOVA test was used in this study to compare the group means.

3.6.6 Reliability and validity test

Reliability is frequently used as a measurement tool to assess the same variables repeatedly and produce the same results (Salkind, 2006). The reliability test procedure aims to raise the reliability measure by increasing the number of variables or observations, using pre-tests and pilot studies, and obtaining the most significant reliable results, which are typically uncommon. According to Sekaran and Bougie (2010), examining the questions' consistency and stability allows for the establishment of the study measures' dependability. The internal consistency of the items related to the Likert scale (Strongly Disagree = (1), Disagree = (2), Moderate = (3), Agree = (4), Strongly Agree = (5) and Unsure = (U)) questions were measured in this study using the Cronbach's Alpha coefficient. The reliability of the scales is evaluated using Cronbach's Alpha, which has a range of values from 0 to 1. A reliability score of $\alpha \geq 0.9$ denotes high reliability; $0.8 \leq \alpha < 0.9$ moderate to high reliability; $0.7 \leq \alpha < 0.8$ moderate reliability; $0.6 \leq \alpha < 0.7$ low to moderate reliability; $0.5 \leq \alpha < 0.6$ low reliability; and $\alpha < 0.5$ inadequate reliability. Sekaran and Bougie (2010) state that scale questions are more dependable and consistent when the measured items are near 1. According to Andrew *et al*. (2010), one of the most widely used techniques for evaluating the consistency and dependability of products is Cronbach's alpha. The survey questionnaires were extensively reviewed by both the supervisor and the co-supervisor to ensure that validity of the data collection instrument used in this study. The review of the survey questionnaires ensures that there is no ambiguity or bias. According to Robinson and Leonard (2018), in-depth examination and improvement of survey questions can greatly minimise ambiguity and bias, resulting in more accurate and trustworthy data gathering.

3.7 Ethical considerations

The Cape Peninsula University of Technology's (CPUT) ethical principles are followed in this study to guarantee anonymity, voluntary involvement, and quality control. The rights and welfare of respondents have been protected by addressing several ethical issues. Prior to their participation, all respondents were asked for their informed permission, guaranteeing that they are completely aware of the goals, methods, and anticipated results of the study. Considering that participation is completely voluntary, respondents are free to stop at any moment without facing any consequences. To ensure anonymity and secrecy, all information collected is handled with the highest discretion, and the identity of the respondents remains hidden. During analysis, replies were aggregated, and identifying information was eliminated from the dataset to avoid tracking down specific individuals. Potential hazards to respondents were carefully evaluated, and the study was designed to reduce any harm, whether physical, psychological, or reputational. To avoid any undue influence, respondents were not compensated or given any incentives. Quality assurance focused on ensuring the accuracy of data, including careful verification of completed forms and conducted computations, to preserve the integrity of the study process. By adhering to these ethical criteria, the study ensured conformity to professional and institutional ethical norms, safeguarding respondents and maintaining the study's validity.

3.8 Chapter conclusion

An outline of the research methods used in the study is presented in this chapter. To fulfil the study's goals and objectives, a quantitative research strategy was used. This chapter focuses on the study's target population, data collection techniques, how to construct a questionnaire survey, response rates, and how to analyse the collected data. To gather and examine the primary and secondary data for the study, questionnaires were used. Mailing is the suggested strategy for administering the questionnaire. The following chapter focuses on utilising descriptive analysis to effectively display and analyse the questionnaire's results.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSIONS

4.1 INTRODUCTION

This chapter examines the information obtained from respondents selected from the entire population, which includes contractors within the province of the Eastern Cape, South Africa. The obtained data was analysed using descriptive analysis, and inferential statistics. Tables and Figures were used to present the results, and the information in the Tables and Figures served as the basis for interpretation. Furthermore, the chapter also offers discussions of the findings to give readers a better understanding of the results and their consequences.

4.2 Response rate

Quantitative data for this study was gathered through a structured questionnaire survey targeting contractors operating in the Eastern Cape Province of South Africa, registered under cidb Grades 5 to 9 GB**.** Data collection involved using online LimeSurvey platforms to reach respondents. Questionnaires were distributed to 201 construction companies in areas including Alfred Nzo, Amathole, Chris Hani, Joe Gqabi, Oliver Reginald Tambo, and Sarah Baartman. Professionals including quantity surveyors, construction managers, site agents, H&S managers, and site technicians were among the responders. A total of 105 fully completed questionnaires were received and 96 incomplete surveys were returned out of 201 that were sent, resulting in a 52.2% response rate. According to Nulty (2008)**,** a response rate of approximately 50% is generally acceptable for mail surveys, provided the sampling and survey implementation processes are robust. This study's response rate is thus within the acceptable range, reflecting good participation given the challenges of survey fatigue and time constraints among industry professionals. However, Edwards et al. (2002) noted that if the responders and non-respondents differ in a systematic way, the response rate may affect the validity of the findings. Larger companies or more seasoned contractors, for example, might not have participated as much, thus the results might not accurately reflect their viewpoints. Efforts were made to mitigate this by targeting a representative sample across various grades and professional roles.

4.3. Demographic information of respondents

4.3.1. Gender of the respondents

Figure 4.1 shows the gender distribution: 53.3% male and 46.7% female**.** Despite the construction industry being male dominated, the nearly equal gender representation in this study highlights an inclusive approach. This balance strengthens the validity of the findings, as it captures diverse perspectives on waste management practices.

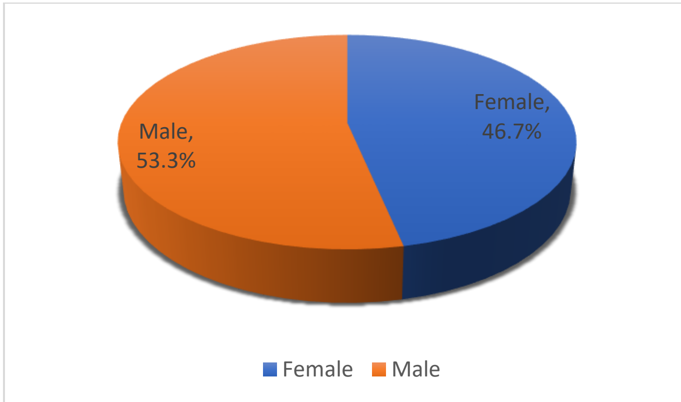

Figure 4.1 Gender of the respondents

4.3.2 Age group of the respondents

Table 4.1 indicates the respondents' age distribution, with the majority 69.5% falling within the 26–39 years range, followed by 23.8% aged 18–25 years. Respondents aged 40–49 years represented only 6.7%, while no respondents were above 50 years. The predominance of younger professionals suggests that the industry is largely managed by a younger workforce, which may impact the prioritisation of innovative waste management strategies.

Table 4.1 Age of the respondents

Age	Frequency	Percent	Cumulative %
18-25	25	23.8	23.8
26-39	73	69.5	93.3
40-49	7	6.7	100.0
50-59	0	0.0	100.0
60 & above	0	0.0	100.0
Total	105	100.0	

4.3.3 Highest qualification of the respondents

Over 80% of the sample is comprised of respondents with a bachelor's degree 46.7% and a national diploma 36.2%, as seen in Table 4.2. 12.3% have educational credentials below matriculation level, while only 3.8% hold a master's degree. The large proportion of respondents with postsecondary education indicates a highly qualified workforce, which improves the accuracy of answers pertaining to waste management's technical components. The very low proportion of respondents who held postgraduate degrees, however, might point to a knowledge gap that could restrict the use of creative waste reduction techniques.

Table 4.2 Educational qualification

Qualification	Frequency	Percent	Cumulative (%)
Matric Certificate	1	1.0	1.0
National Diploma	38	36.2	37.1
Bachelor’s Degree	49	46.7	83.8
Master’s Degree	4	3.8	87.6
Other	12	12.3	100.0
Total	105	100.0	

4.3.4 Profession of the respondents

As shown in Table 4.3 below, among the respondents that participated in the questionnaire survey, 58.1% of the respondents were quantity surveyors, 17.1% of the respondents were construction managers, 1.9% of the respondents were site agents, 4.8% were project managers, 1.9% were H&S managers, 7.6% were site technician while 8.6% were others such as site foreman and H&S representatives. With a considerable 58.1%, the results showed that quantity surveyors made up most of the respondents. Perceptions of waste management, drivers and challenges may also be influenced by respondents' professional backgrounds, technical occupations may place greater emphasis on practical difficulties than on strategic or policy concerns.

Table 4.3 Respondents profession

Profession	Frequency	Percent	Cumulative (%)
Quantity Surveyor	61	58.1	58.1
Construction Manager	18	17.1	75.2
Site Agent	2	1.9	77.1
Project Manager	5	4.8	81.9
H&S Manager	2	1.9	83.8
Site Technician	8	7.6	91.4
Other	9	8.6	100.0
Total	105	100.0	

4.3.5 Working experience of the respondents

According to Table 4.4, most respondents are early-career professionals, with 81.9% having 0–5 years of experience. Just 18.1% have worked for more than five years. The depth of insights regarding long-term waste management trends and strategies may be impacted by this lack of industry expertise. The results may be skewed by younger professionals who are more concerned with short-term operational difficulties than with long-term problems. To balance various viewpoints, the study made sure that respondents came from a variety of roles and grades.

Table 4.4 Respondents working experience

Working experience	Frequency	Percent	Cumulative (%)
0- 5 years	86	81.9	81.9
6- 10 years	12	11.4	93.3
11- 15 years	3	2.9	96.2
16- 20 years	3	2.8	99.0
21- 25 years	1	1.0	100.0
Total	105	100.0	

4.3.6 cidb grade of the contractors

Figure 4.2 displays the cidb grade of the construction companies that employed the respondents. As seen in Figure 4.2, 46.7% of contractors fell into the Grade 5 category, followed by 11.4% of contractors in the Grade 6 category, 13.3% of contractors in the Grade 7 category, 10.5% of contractors in the Grade 8 category, and 18.1% of contractors in the Grade 9 category. With a noteworthy 46.7%, Figure 4.2 showed that most active contractors in the Eastern Cape Province were in Grade 5. Smaller companies are more prevalent in the Eastern Cape Province, which is reflected in the substantial number of lower-grade contractors.

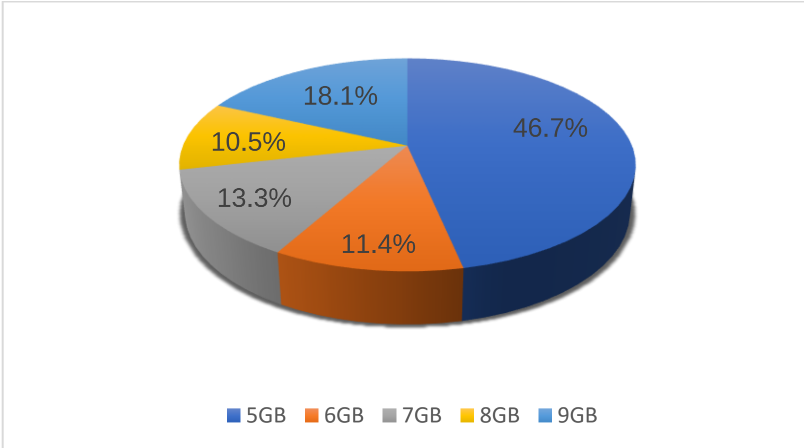

Figure 4.2 cidb Grade of the contractors

4.4. Reliability test

A reliability test is used to assess the scaled questions in the waste management study among contractors, which shows differing degrees of internal consistency between the study's objectives and sub-objectives. Regarding the first objective, which focuses on contractors' perceptions of waste management, it is found that cost concerns have a low reliability (α = 0.781), indicating some response inconsistency. On the other hand, there is a moderate level of reliability (α = 0.836 and α = 0.825, respectively) for management attitudes towards waste management and the lack of training to reinforce the importance of waste management practices, suggesting a generally consistent perspective among respondents. Strong agreement on environment related factors is reflected in the second objective, which examines the key drivers for contractor's waste management practices. The results indicate good dependability for environment-related factors (α = 0.940). There is a consistent reaction to both the economic and social drives, as indicated by the moderate reliability of both economical and socially related factors (α = 0.841 and α = 0.883, respectively). Strong agreement on the challenges experienced by contractors related to reduction of construction waste is indicated by the third objective, which addresses the issues contractors have in decreasing construction waste and exhibits good dependability (α = 0.956). High reliability is regularly demonstrated across all sub-objectives of the fourth objective, which assesses construction waste management practices. The efficacy and consistency of various processes are highly agreed upon by respondents with regards to effective waste management on construction sites (α = 0.948), procurement (α = 0.911), handling (α = 0.921), operation (α = 0.905), and culture (α = 0.938). A high Cronbach's alpha suggests that respondents generally agree that waste management strategies are beneficial, and that the metrics employed to evaluate their performance are trustworthy. This is supported by Sekaran and Bougie (2010) who identified that the reliability of the scale is indicated by a high Cronbach's alpha score, which also shows that the test's items offer consistent findings. Mbadugha *et al.* (2021) highlighted the need of ensuring that waste management strategies are not only implemented but also positively perceived by those directly engaged in construction-related activities.

Table 4.5 Reliability test

	Headings	No. of Items	Cronbach's Alpha	Rank
Perceptions of contractors regarding waste management	Cost concerns	10	0.781	Low
	Management attitudes towards construction waste management	10	0.836	Moderate
	Lack of training to reinforce the importance of waste management practices	8	0.825	Moderate
Average			**0.814**	**Moderate**
Key drivers for contractor' s waste management practices	Environment-related factors	13	0.940	High
	Economically related factors	7	0.841	Moderate
	Socially related factors	7	0.883	Moderate
Average			**0.888**	**Moderate**
Challenges experienced by contractors related to reduction of construction waste	Challenges experienced by contractors related to reduction of construction waste	30	0.956	High
Average			**0.956**	**High**

Construction waste management practices	Effective waste management on construction site	10	0.948	High
	Procurement	7	0.911	High
	Handling	9	0.921	High
	Operation	6	0.905	High
	Culture	8	0.938	High
Average			**0.925**	High
Sum	**All questions combined**	**125**	**0.890**	**Moderate**

4.5 Assessing effective mechanism for construction waste reduction in South Africa

4.5.1 The perceptions of contractors regarding construction waste management

4.5.1.1 Cost concerns

On the 5-point Likert scale (Strongly Disagree, Disagree, Moderate, Agree, Strongly Agree, and Unsure), the respondents were asked to rate their degree of agreement regarding cost concerns regarding construction waste management in South Africa. Waste management practices which can save contractors' finances in the long run were ranked highest with a mean value (MV=4.27) and 84.7% of the respondents agreed that waste management practices can save contractors' finance in the long run, 5.7% of respondents were moderate, while 7.7% of respondents disagreed, and about 1.9% of respondents were unsure whether the waste management practices can save contractors’ finance in the long run or not. Waste disposal costs are a significant consideration came in second place, with (MV=4.18) and 82.3% of the respondents agreed that waste disposal costs are a significant consideration, 8.6% of respondents were moderate, while 4.8% of respondents have disagreed that waste disposal costs are a significant consideration, and about 3.7% of respondents were unsure. A total of 75.2% of the respondents agreed that prioritising short-term savings over long-term benefits can be a concern with cruising MV of 3.97 and this factor is ranked third highest. A total of 13.3% of respondents were moderate, while 8.6% of respondents disagreed about the concern of prioritising short-term savings over long-term benefits, and about 2.9% of respondents were unsure. The respondents' lowest ranking factor for cost concern is ‘educating workers on waste management practices can be costly’, with (MV=3.02) and 34.2% of the respondents agreed that educating workers on waste management practices can be costly, and 24.8% of respondents were moderate. In comparison, 39.1% of respondents disagreed about the cost of educating workers on waste management practices as a cost concern in waste management, and about 1.9% of respondents were unsure. Based on the results it is evident that implementing effective strategies to reduce construction waste can save money for contractors in the Eastern Cape province as presented in Table 4.6. It is critical to emphasize that all MVs are higher than 3.00 and that the MV for the combined cost-related factors is 3.80.

Table 4.6 Cost concerns

Cost concerns	Frequency	Unsure	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std.	Rank
Waste management practices can save contractors' finance in the long run	105	1.9	5.7	2.0	5.7	31.4	53.3	4.27	1.068	1
Waste disposal costs are a significant consideration	105	3.7	2.9	1.9	8.6	44.8	38.1	4.18	.899	2
Prioritising short-term savings over long-term benefits can be a concern	105	2.9	3.8	4.8	13.3	43.8	31.4	3.97	1.009	3
Concerns arise about diverting resources (labour and equipment) to waste management	105	12.3	1.9	2.9	18.1	41.0	23.8	3.93	.899	4
Contractors fear losing bids if waste management increases project costs	105	3.9	5.7	6.7	13.3	39.0	31.4	3.87	1.128	5
Clients' budget limitations may limit funds allocated for waste management	105	4.7	5.7	4.8	14.3	43.8	26.7	3.85	1.077	6
Price fluctuations in recycling and disposal services can impact budgets	105	3.8	3.8	5.7	18.1	52.4	16.2	3.74	.945	7
Complying with waste regulations may involve added expenses	105	3.8	2.9	18.1	15.2	36.2	23.8	3.62	1.139	8
Setting up waste management infrastructure requires upfront investment	105	4.9	4.8	15.2	12.2	44.8	18.1	3.59	1.120	9
Educating workers on waste management practices can be costly	105	1.9	8.6	30.5	24.8	19.0	15.2	3.02	1.221	10
Average	**105**							**3.80**		

In Objective 1, which explores the perceptions of contractors regarding construction waste management, cost concerns were selected for Analysis of Variance (ANOVA) analysis to determine whether contractors across different cidb Grades 5–9 had significant differences in their perceptions of the financial implications of waste management practices. Cost concerns focus on issues like waste disposal costs, resource allocation, and the fear of increased project costs, which are essential factors influencing contractors' decisions about waste management. By using ANOVA, the study aimed to assess whether contractors from different grading levels shared similar or differing views on how waste management affects project budgets. ANOVA is a statistical technique used to evaluate differences in the means across two or more groups (Pallant, 2020). In this study, ANOVA testing was conducted to ascertain whether there were significant differences between the various cidb Grades 5–9 contractors with reference to cost concerns. This was done to evaluate whether contractors had a consensus on their perceptions regarding construction waste management. The findings of the ANOVA test, presented in Table 4.7, show that there are no significant differences in cost concerns between the various cidb gradings, as the significance level is $p > 0.05$.

The results indicate marginal statistical differences, with a p-value of 0.645 and an F-value of 0.627, regarding the perception that waste management practices can save contractors finance in the long run. However, this difference is minimal and suggests that any detected variations between groups are likely due to random fluctuations, as the p-value exceeds the 0.05 threshold. Other factors such as concerns about diverting resources (labour and equipment) to waste management, waste disposal costs, and the tendency to prioritize short-term savings over long-term benefits were also evaluated in the ANOVA. Despite these concerns, no statistically significant variations were found across the groups, as p-values for these factors were also above 0.05, indicating that the observed variations were likely due to chance rather than substantial differences in contractors' cost-related beliefs or worries.

The findings of the ANOVA analysis are consistent with previous research that found differing opinions about the long-term financial benefits of waste management practices in construction (Udawatta et al., 2015). However, no discernible difference was found in other factors related to cost concerns, such as the expense of disposing of waste and worries about allocating resources to waste management, between the groups. This is in line with findings from Daian and Ozarska (2009), which suggest that contractors frequently encounter similar challenges and consistent factors when managing waste-related expenses in the construction industry.

Thus, the selection of cost concerns for ANOVA analysis in this study was to assess the financial barriers to waste management from the perspective of contractors across different cidb grading levels, providing insight into whether these concerns influenced their approach to waste management in a consistent or variable manner.

Table 4.7 ANOVA Test on cost concerns

ANOVA						
		Sum of Squares	Df	Mean Square	F	Sig.
Waste management practices can save contractors finance in the long run	Between Groups	2.902	4	.726	.627	.645
	Within Groups	113.486	98	1.158		
	Total	116.388	102			
Waste disposal costs are a significant consideration	Between Groups	1.368	4	.342	.413	.799
	Within Groups	79.424	96	.827		
	Total	80.792	100			
Concerns arise about diverting resources (labour and equipment) to waste management	Between Groups	2.574	4	.644	.788	.536
	Within Groups	71.034	87	.816		
	Total	73.609	91			
Prioritising short-term savings over long-term benefits can be a concern	Between Groups	1.576	4	.394	.377	.824
	Within Groups	101.336	97	1.045		
	Total	102.912	101			
Contractors fear losing bids if waste management increases project costs	Between Groups	5.530	4	1.382	1.090	.366
	Within Groups	121.797	96	1.269		
	Total	127.327	100			
Clients' budget limitations may limit funds allocated for waste management	Between Groups	2.859	4	.715	.607	.659
	Within Groups	111.891	95	1.178		
	Total	114.750	99			
Complying with waste regulations may involve added expenses	Between Groups	3.456	4	.864	.657	.623
	Within Groups	126.247	96	1.315		
	Total	129.703	100			

Educating workers on waste management practices can be costly	Between Groups	3.221	4	.805	.530	.714
	Within Groups	148.741	98	1.518		
	Total	151.961	102			
Setting up waste management infrastructure requires upfront investment	Between Groups	5.086	4	1.271	1.014	.404
	Within Groups	119.104	95	1.254		
	Total	124.190	99			
Price fluctuations in recycling and disposal services can impact budgets	Between Groups	1.136	4	.284	.309	.871
	Within Groups	88.171	96	.918		
	Total	89.307	100			

From Table 4.8 it is notable that ‘resistance to adopting innovative waste reduction practices’ was ranked first with (MV=4.07) and 77.2% of the respondents agreed that resistance to adopting innovative waste reduction practices is regarded as a significant factor contributing to construction waste in the Eastern Cape Province, 10.5% of respondents were moderate, while 5.7% of respondents disagreed about contractors’ resistance to adopting innovative waste reduction practices, and approximately 6.6% of respondents were unsure. Poor communication from supervisors regarding waste management is ranked second, with (MV=4.02), and 78.1% of the respondents agreed that poor communication from supervisors regarding waste management is a contributing factor for a significant amount of waste produced on site; 12.4% of respondents were moderate, while a 7.7% of respondents disagreed on this management attitude towards construction waste management and of poor communication from supervisors regarding waste management, about 1.8% of respondents were unsure. Nonetheless, ‘inconsistent enforcement of waste management rules’ was ranked thirdly with (MV=3.97) and 75.2% of the respondents explicitly agreed with this concern, underlining the significance of this challenge in the construction industry; 13.3% of respondents were moderate, while 8.6% of respondents \disagreed, and about 6.7% of respondents were uncertain about the matter. Notably, the least rated concern according to the respondents is ‘construction waste management is time-consuming for contractors’, with (MV=3.46) and 55.2% of the respondents agreeing to time demands associated with waste management, 17.1% of respondents were moderate, while 25.7% of respondents disagreed, and only 2.0% of respondents were unsure. Notably, the combined factors have (MV=3.85).

Table 4.8 Management attitudes towards construction waste management

Management attitudes	Frequency	Unsure	Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree	Mean	Std.	Rank
Resistance to adopting innovative waste reduction practices	105	6.6	1.9	3.8	10.5	46.7	30.5	4.07	.888	1
Poor communication from supervisors regarding waste management	105	1.8	1.0	6.7	12.4	47.6	30.5	4.02	.896	2
Inconsistent enforcement of waste management rules	105	6.7	1.9	2.9	17.1	45.7	25.7	3.97	1.021	3
Lack of supervision	105	3.9	1.9	7.6	13.3	43.8	29.5	3.95	.973	4
Short-term cost savings over sustainability	105	5.5	1.0	4.8	21.0	44.8	22.9	3.89	.868	5
Blame-shifting and lack of accountability	105	4.7	2.9	7.6	16.2	43.8	24.8	3.84	1.002	6
Project requirements influence contractors' perception regarding waste management approach	105	5.8	0.0	7.6	21.9	45.7	19.0	3.81	.853	7
Undermining compliance with waste management regulations	105	8.6	1.9	11.4	14.3	41.9	21.9	3.77	1.021	8
Disregard for proper training and education	105	6.6	4.8	8.6	17.1	42.9	20.0	3.69	1.069	9
Construction waste management is time-consuming for contractors	105	2.0	6.7	19.0	17.1	33.3	21.9	3.46	1.227	10
Average	**105**							**3.85**		

4.5.1.4 Exploratory factor analysis (EFA)

Exploratory factor analysis (EFA) was adopted in this study to identify latent dimensions influencing management attitudes towards construction waste management. In Objective 1, which explores the perceptions of contractors regarding construction waste management, the study includes three factors: cost concerns**,** management attitudes towards construction waste management, and lack of training to reinforce the importance of waste management practices. Among these, management attitudes towards construction waste management were selected for EFA because it encompasses subjective and multifaceted perceptions that are inherently interrelated. This necessitated a method capable of identifying underlying dimensions or latent factors within the data.

A thorough analysis consisting of the evaluation of 10 different management attitudes was carried out to determine which were most significant in shaping contractors' views. EFA is particularly suited for analysing management attitudes, as this construct often comprises multiple correlated variables that reflect contractors' beliefs, values, and practices. By applying EFA, the study aimed to simplify the 10 variables related to management attitudes into a smaller set of meaningful components. Additionally, the method helped uncover latent dimensions that explain the most variance in contractors' management attitudes, ensuring that the variables within the construct were cohesive and represented distinct underlying factors. This reduction and classification procedure validated the consistency of the quantitative study. Furthermore, the variables were extracted using principal component analysis (PCA) to enhance the robustness of the findings.

4.5.1.4.1 KMO adequacy and Bartlett's test

Pallant (2020) states that factor analysis can be carried out in three primary steps to assess the study's significance. The Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) tests were used to identify the variables influencing management attitudes toward construction waste management in South Africa. Table 4.9 displays the findings from applying the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's sphericity test. Together, these analytical instruments provide the fundamental standards needed to assess the statistical significance of factor analysis data. Pallant (2020) suggests that the KMO value for significant factor analysis should have a range of 0 to 1, with a minimum value of 0.60. According to Allen *et al.* (2017), the Bartlett test indicates the link between the variables, and for this study, the Bartlett test conditions are considered. For factor analysis to be deemed suitable and significant, the corresponding significance level's Bartlett test must be $p<0.005$. The KMO value of 0.868, which is more than the minimal value of KMO 0.60, is shown in Table 4.8. Additionally, the sphericity significance level for the Bartlett's test was p=0.001, which is lower than the required minimum of p<0.005. These results substantiate the minimal requirements and show that factor analysis is feasible.

Table 4.9 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.868
Bartlett's Test of Sphericity	Approx. Chi-Square	264.320
	Df	45
	Sig.	<.001

4.5.1.4.2 Principal components of management attitudes towards construction waste management

The factor extraction process was carried out using Principal Component Analysis (PCA), a technique commonly recommended for this purpose (Pallant, 2020). Table 4.10 shows the total variance explained by components, indicating two components with eigenvalues greater than 1: 4.359 and 1.098, which cumulatively explain 54.57% of the variance. The main factor impacting management attitudes toward construction waste management in South Africa is component 1, which accounts for 43.59% of the variance. With an eigenvalue of 1.098, component 2 adds 10.98% to the variance. These elements, which represent the fundamental elements impacting management choices, were given the names "support for compliance with waste management practices" for component 1 and "barriers to effective waste management" for component 2. Component 1 highlights attitudes towards regulatory compliance, consistent enforcement of waste management rules, and the need for proper training and education to support compliance. In contrast, component 2 captures barriers such as perceived time and resource constraints, indicating practical challenges faced by managers in implementing waste management strategies. This analysis aligns with the eigenvalues and percentage variance explained, providing a nuanced understanding of the key factors shaping management attitudes. These insights contribute to a more comprehensive view of construction waste management practices in the SACI, highlighting both proactive compliance and the challenges that managers encounter in the field.

Table 4.10 Total Variance Explained by components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.359	43.585	43.585	4.359	43.585	43.585
2	1.098	10.977	54.563	1.098	10.977	54.563

3	.905	9.050	63.613			
4	.744	7.436	71.049			
5	.662	6.623	77.672			
6	.652	6.525	84.197			
7	.510	5.097	89.293			
8	.387	3.870	93.164			
9	.348	3.478	96.641			
10	.336	3.359	100.000			
Extraction Method: Principal Component Analysis.						

4.5.1.4.3 Summary of factor analysis on management attitudes towards construction waste management in construction sites

The factor analysis results presented in Table 4.11 reveal that all factor loadings surpass the .30 threshold, confirming the relevance of the variables to their respective components. Variables with loadings below this threshold were excluded to emphasize the most significant factors. 2 components were identified: component 1, titled "undermining compliance with waste management regulations" and component 2, titled "project requirements influence contractors' perception regarding waste management approach". Component 1 encompasses variables that reflect how management attitudes and practices undermine compliance with waste management regulations. Key variables, such as "undermining compliance with waste management regulations", "resistance to adopting innovative waste reduction practices" and "inconsistent enforcement of waste management rules", point to issues like poor enforcement, lack of accountability, and ineffective communication. The high factor loadings of these variables highlight their central role in understanding the negative management attitudes that obstruct effective waste management practices on construction sites. Component 2 examines how project-specific requirements influence contractors' perceptions of waste management. Variables in this component, such as "project requirements influence contractors' perception regarding waste management approach" and "construction waste management is time-consuming for contractors", emphasize the impact of project demands on contractors' waste management strategies. These findings suggest that contractors tend to prioritize immediate project goals, like meeting deadlines and staying within budget, over long-term waste management objectives, viewing waste management as an additional burden.

Table 4.11 Component Matrix[a]

	Component

	Undermining compliance with waste management regulations	*Project requirements influence contractors' perception regarding waste management approach*
C1: Undermining compliance with waste management regulations	.768	
Resistance to adopting innovative waste reduction practices	.765	
Inconsistent enforcement of waste management rules	.759	
Blame-shifting and lack of accountability	.715	
Lack of supervision	.712	
Disregard for proper training and education	.704	
Poor communication from supervisors regarding waste management	.700	
Short-term cost savings over sustainability	.653	
Construction waste management is time-consuming for contractors	.320	
C2: Project requirements influence contractors' perception regarding waste management approach		.753
Construction waste management is time-consuming for contractors		.671
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

4.5.1.4.4 Lack of training to reinforce the importance of waste management practices

Table 4.12 presents the findings related to a lack of training to reinforce the importance of waste management practices. Five-point ratings on a 5-point scale were used by the respondents to indicate their degree of agreement: Strongly Disagree, Disagree, Moderate, Agree, Strongly Agree, and Unsure. As presented in Table 4.12 'insufficient training can lead to ignorance of waste management regulations' was ranked first with (MV=4.29) and 85.7% of the respondents agreed indicating a substantial majority recognising the significance of training in preventing ignorance of waste management regulations, and 9.5% of respondents were moderate. Conversely, 3.8% of respondents disagreed, indicating a minority viewpoint that differs from the majority opinion regarding the importance of training, and 1.0% of respondents were unsure. Lack of awareness regarding wastage of resources, including materials that could be reused or recycled, was ranked second, with (MV=4.14). A huge majority of respondents, namely 81.9%, agreed with this statement, suggesting that there is a general lack of understanding among respondents concerning resource wastage and potential recycling opportunities; 15.2% of those surveyed were in the moderate range, 1.0% of those surveyed disagreed and about 1.9% of respondents were unsure. Table 4.12 indicates that ‘lack of training regarding safety hazards for workers and site occupants’ is ranked third with (MV=4.13). There is broad agreement that workers and site occupants require better training in safety awareness, as seen by the overwhelming 84.7% of respondents who agreed with this statement. Furthermore, 7.6% of those surveyed had a moderate opinion. Conversely, 6.7% of respondents disagreed, representing a minority perspective on the effectiveness of current training programmes in addressing safety hazards, and approximately 1.0% of respondents were unsure.

From the results, the least ranked factor is: lack of training related to worksite cleanness fosters effective adoption of waste management practices, with (MV=3.98) and 74.3% of the respondents agreeing, showing that a sizeable majority of respondents believe that training is essential for keeping work sites clean and implementing efficient waste management practices, 14.3% of respondents were moderate, while 6.7% of respondents disagreed, and about 4.7% of respondents were unsure. The average MV for the combined factors is 4.10, and it is noteworthy to emphasise that all MVs are higher than 3.00.

Table 4.12 Lack of training to reinforce the importance of waste management practices

Lack of training	**Frequency**	**Unsure**	**Strongly Disagree**	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std.**	**Rank**
Insufficient training can lead to ignorance of waste management regulations	105	1.0	0.0	3.8	9.5	40.0	45.7	4.29	.797	1
Lack of awareness regarding wastage of resources, including materials that could be reused or recycled	105	1.9	0.0	1.0	15.2	51.4	30.5	4.14	.701	2

Lack of training regarding safety hazards for workers and site occupants	105	1.0	1.0	5.7	7.6	49.5	35.2	4.13	.860	3
Inadequate training relating to environmental harm from improper waste disposal, including hazardous materials	105	3.8	1.9	0.0	14.3	52.4	27.6	4.08	.783	4
Lack of training to reinforce the importance of responsible waste management	105	2.7	1.0	2.9	12.4	54.3	26.7	4.06	.781	5
Inadequate training related to communication with subcontractors about waste management	105	1.9	1.0	3.8	14.3	49.5	29.5	4.05	.833	6
Workers' training in waste handling is essential	105	5.7	3.8	3.8	6.7	50.5	29.5	4.04	.957	7
Training related to worksite cleanness fosters effective adoption of waste management practices	105	4.7	1.0	5.7	14.3	47.6	26.7	3.98	.876	8
Average	**105**							**4.10**		

4.5.1.5 Discussion of findings of contractors' perception regarding construction waste management

The findings from Table 4.6 highlight contractors' perceptions regarding cost factors enabling effective waste management practices. Contractors generally believe that implementing waste management practices can result in long-term financial savings (MV=4.27). This aligns with Park and Tucker (2017) assertion that poor waste management can lead to project delays, rework, higher disposal costs, and even legal penalties, which collectively inflate overall project expenses. Similarly, Nawaz *et al.* (2023) emphasise that contractors who adopt proactive waste management strategies not only achieve cost savings but also enhance project profitability. Waste disposal costs emerged as a significant factor, ranked second highest (MV=4.18). Esa *et al.* (2017) advocate for effective waste minimisation practices, which not only reduce disposal expenses but also promote environmental sustainability, ultimately leading to increased profitability for businesses. This finding corroborates Jikeka *et al.* (2020) claim that the cost of disposing of construction waste can be as low as 0.5% of the average project budget, highlighting the economic advantage of minimising waste generation. The prioritisation of short-term savings over long-term benefits was ranked third (MV=3.97). Aboginije *et al.* (2020) caution that focusing on immediate financial gains can undermine long-term sustainability goals, as companies may avoid investing in sustainable practices that require substantial initial costs but offer significant long-term advantages. Mbadugha *et al.* (2021) further highlight that short-termism can impede proactive strategies, particularly those addressing social, economic, and environmental sustainability.

The ANOVA findings highlight that cost concerns are not significantly differentiated among contractors of various cidb Grades 5–9, as evidenced by the high p-values (all >0.05) across the analysed variables as presented in Table 4.7. For instance, the perception that "waste management practices can save contractors finance in the long run" had a p-value of 0.645, indicating minimal differences among groups. Similar results were observed for variable such as "waste disposal costs are a significant consideration" ($p = 0.799$) and "concerns arise about diverting resources to waste management" ($p = 0.536$). These outcomes suggest that contractors, regardless of their cidb grading, generally perceive cost-related challenges to be uniformly significant. This finding aligns with prior research by Udawatta *et al.* (2015) and Daian and Ozarska (2009), which identified cost as a persistent barrier to adopting sustainable waste management practices. Contractors frequently face difficulties with upfront investments for infrastructure, educating workers, and managing fluctuating prices in recycling and disposal services. However, the marginal variations noted in factors such as "setting up waste management infrastructure requires upfront investment" ($p = 0.404$) suggest potential inconsistencies in how contractors prioritise or approach these challenges. This uniformity underscores the need for systemic interventions, such as subsidies or incentives, to alleviate cost burdens and encourage waste management practices.

The findings from Table 4.8 reveal that resistance to adopting innovative waste reduction practices is the most significant challenge, ranked first with (MV=4.07). This aligns with Esa *et al.* (2017), who stress the importance of understanding current strategies and anticipating future directions in waste management to drive improvements in the construction industry. Kabirifar *et al.* (2020) highlight the critical role that organisational attitudes toward waste and recycling play in influencing behaviours, indicating that resistance to change may hinder the adoption of innovative practices. The results also indicate that poor communication from supervisors regarding waste management (MV=4.02) is a substantial barrier. According to Gamil and Rahman (2021), poor communication frequently results in misunderstandings and a lack of clarity on waste management procedures, which raises the amount of waste produced. Supervisors can lessen this problem, according to Fei *et al.* (2021), by giving clear directions and using efficient communication techniques. Additionally, Udawatta *et al.* (2015) recommend strengthening stakeholder communication channels and cultivating an open culture to support sustainable waste management methods. Inconsistent enforcement of waste management rules was ranked third (MV=3.97). This finding is consistent with Blismas and Wakefield (2008), who identify the irregular application of waste management regulations as a significant impediment to reducing waste generation. Kabirifar *et al.* (2020) further explain that when rules are inconsistently enforced, contractors may perceive waste management as less critical, leading to negligent behaviours and an increase in waste generation.

Component 1: Undermining compliance with waste management regulations

This principal factor explained the most variance and was defined by nine variables: undermining compliance with waste management regulations (.768), resistance to adopting innovative waste reduction practices (.765), inconsistent enforcement of waste management rules (.759), blame-shifting and lack of accountability (.715), lack of supervision (.712), disregard for proper training and education (.704), poor communication from supervisors regarding waste management (.700), short-term cost savings over sustainability (.653) and construction waste management is time-consuming for contractors (.320).

The findings reveal critical barriers undermining compliance with waste management regulations, as discussed in Table 4.11. Gunningham and Sinclair (2019) argue that non-compliance with waste management legislation can result from various acts or inactions by individuals, businesses, and government agencies. Similarly, Yuan (2017) found that many contractors struggle to meet waste management requirements, leading to violations and increased waste production. Spisáková *et al.* (2021) further identify misconceptions about regulations and the belief that enforcement is lax as significant contributors to non-compliance. Resistance to adopting innovative waste reduction practices remains a substantial challenge. Akadiri *et al.* (2012) and Nagapan *et al.* (2012) emphasise that resistance often stems from perceived risks and uncertainties associated with new practices. This reluctance hinders the effective implementation of waste management innovations. Inconsistent enforcement of regulations exacerbates these challenges. Blismas and Wakefield (2008) and Nyika *et al.* (2019) assert that inconsistent enforcement undermines contractor confidence, leading to reluctance in adhering to waste management standards. The findings also highlight blame-shifting and lack of accountability as barriers. According to Tafesse *et al.* (2022), project teams without clear accountability tend to exhibit poor waste management outcomes, as no one assumes ownership of waste reduction. Li *et al.* (2019) adds that ambiguous roles and responsibilities often lead to a lack of accountability, further impeding effective waste management practices. A lack of supervision is another significant issue identified in the findings. Ajayi and Oyedele (2018) stress that inadequate monitoring results in increased waste generation and substandard waste management practices. Udawatta *et al.* (2015) highlight the need for effective supervision to ensure compliance with waste management protocols. The disregard for proper training and education significantly impacts waste management efforts. The study findings underscore that insufficient training often leads to ignorance of waste management regulations (MV=4.29). Esa *et al.* (2017) observe that many contractors lack sufficient knowledge of waste management rules, contributing to improper waste handling. Kabirifar *et al.* (2020) emphasise the need for comprehensive training programmes to address these gaps. A lack of awareness regarding resource wastage, including reusable or recyclable materials (MV=4.14), further compounds the issue. Dosumu and Aigbavboa (2019) and Hasmori *et al.* (2020) support this, highlighting that inadequate knowledge leads to valuable materials being discarded, exacerbating environmental degradation. The study also found that a lack of training on safety hazards for workers and site occupants (MV=4.13) is a critical concern. Abarca-Guerrero (2017) corroborates this finding, revealing that insufficient safety training prevents workers from recognising and mitigating potential hazards, underscoring the need for robust safety training programmes. Poor communication from supervisors regarding waste management policies further hinders compliance. Zorpas (2020) states that inadequate communication leads to misunderstandings and non-compliance among workers. Lu *et al.* (2017) highlight the importance of clear, consistent communication from supervisors for successfully implementing waste management practices. Contractors' prioritisation of short-term cost savings over long-term sustainability is another notable challenge. Polat *et al.* (2017) and Huang *et al.* (2018) highlight that economic pressures often lead contractors to prioritise immediate cost reductions over sustainable waste management practices. Finally, the perception that waste management is time-consuming (Yuan, 2017; Bao *et al.,* 2020) deters contractors from adopting efficient practices, as it is viewed as a distraction from core construction tasks.

Component 2: Project requirements influence contractors' perception regarding their waste management approach.

Project requirements influence contractors' perception regarding the waste management approach (.753), that construction waste management is time-consuming for contractors (.671). Contractors' approaches to waste management are significantly influenced by the requirements and size of the construction projects they are working on. According to Yuan (2017), contractors tend to implement more systematic and rigorous waste management strategies when working on projects with strict regulations, as these projects demand a more structured approach. Conversely, projects with ambiguous or lax waste management regulations often lead to less structured procedures, as contractors may prioritize other aspects of the project over waste management, as noted by Tam et al. (2018). This situation highlights a common challenge in the construction industry, where contractors view waste management as an additional burden that complicates the construction process. Rose and Stegemann (2018) argue that this perception is rooted in the extra effort required to manage waste, which contractors see as detracting from the core tasks of the project. Furthermore, Wang et al. (2020) contend that the complexity of project management increases when contractors must coordinate with waste disposal providers and comply with legal standards, further supporting the notion that waste management is perceived as a time-consuming and cumbersome process.

The findings from Table 4.12 revealed that insufficient training can lead to ignorance of waste management regulations with (MV=4.29). This result is consistent with that of Esa et al. (2017), who observe that most contractors have a little knowledge about the rules and regulations that now control how waste is handled and disposed of. Kabirifar et al. (2020) highlight the necessity for thorough training programmes specifically designed to fill in the knowledge and comprehension gaps regarding waste management practices in the construction industry. The study's findings illuminate a concerning lack of awareness regarding wastage of resources, including materials that could be reused or recycled (MV=4.14). This is supported by Dosumu and Aigbavboa (2019), who noted that insufficient knowledge leads to valuable materials being thrown away rather than being recycled, which contributes to the creation of unnecessary waste and environmental degradation. According to Hasmori et al. (2020), a major obstacle in the construction industry is a lack of awareness regarding waste management techniques and approaches among local contractors, and the construction workforce. Lack of training regarding safety hazards for workers and site occupants (MV=4.13) was ranked third by the respondents. This finding was supported by Abarca-Guerrero (2017) who revealed that lack of training causes construction workers to be unable to recognize and manage potential dangers. Abarca-Guerrero (2017) further emphasized the necessity of strong safety training programs.

4.6 Key drivers for contractor’s waste management practices

4.6.1 Environment-related factors

Table 4.13 shows the Relative Importance Index (RII) of the key drivers for contractor’s waste management practices along with the corresponding ranking and their importance level. Ratings of opinions on a 5-point Likert scale are based on the following criteria in terms of their importance in environmental factors. Scale was used in the following order: 1 = Strongly Disagree, 2 = Disagree, 3 = Moderate, 4 = Agree and 5 = Strongly Agree. It is important to note that ‘unsure’ responses were excluded because the RII approach explicitly requires the use of a 5-point Likert scale (Sakhare & Patil, 2019). It is clear as presented in Table 4.13 that the respondents give priority to waste reduction and recycling as it is ranked highest with an RII of 0.885. Water conservation and management, with an RII of 0.880, was rated second. Resource efficiency was rated third with an RII of 0.866. Climate resilience planning and erosion and sediment control were rated least with RII of 0.796.

Table 4.13 Relative importance index (RII) on environment related factors

Environment-related factors	5	4	3	2	1	RII	Rank
Waste reduction and recycling	200	196	24	8	1	0.885	1
Water conservation and management	195	184	39	8	1	0.880	2
Resource efficiency	170	196	48	6	0	0.866	3
Sustainable construction practices	170	208	30	10	0	0.862	4

Hazardous materials management	165	208	30	14	0	0.860	5
Environmental regulations	165	208	36	6	1	0.858	6
Renewable energy integration	175	176	48	12	0	0.847	7
Energy efficiency measures	130	220	54	6	0	0.845	8
Biodiversity protection	180	152	60	10	0	0.829	9
Soil and site remediation	145	196	51	8	0	0.825	10
Air pollution control	175	172	30	18	1	0.816	11
Climate resilience planning	160	160	48	18	0	0.796	12
Erosion and sediment control	135	184	60	6	1	0.796	12

4.6.2 Economical related factors

According to the examination of aspects connected to economical related factors, contractors view recycling opportunities as the most important, as evidenced by the highest RII of 0.860. This suggests that as a major economic driver for waste management practices, contractors give top priority to chances to recycle materials. Material costs are closely followed, with an RII of 0.854, highlighting the significance of cost concerns in the acquisition and use of materials. Ranked third as presented in Table 4.14 was regulatory compliance cost, with an RII of 0.833. This factor emphasises the financial consequences of following regulations.

Table 4.14 Relative importance index (RII) on economical related factors

Economical related factors	**5**	**4**	**3**	**2**	**1**	**RII**	**Rank**
Recycling opportunities	150	212	45	10	0	0.860	1
Material costs	120	244	42	6	2	0.854	2
Regulatory compliance costs	130	228	36	8	2	0.833	3
Cost of disposal	120	228	45	8	2	0.831	4
Project budget constraints	110	200	60	10	0	0.784	5
Competition and market differentiation	110	200	60	6	0	0.775	6
Tax incentives	80	188	54	16	2	0.701	7

4.6.3 Social related factors

The most significant social related factor is the public awareness with the highest RII of 0.880. This factor emphasises how crucial it is to raise public knowledge as a major driver for better waste management practices. With an RII of 0.864, adherence to industry standards comes in second, highlighting the importance of following the industry set norms. Educational initiatives were ranked third an RII of 0.860; this encourages construction workers to be more knowledgeable about waste management.

Table 4.15 Relative importance index (RII) on Social related factors

Social related factors	**5**	**4**	**3**	**2**	**1**	**RII**	**Rank**
Public awareness	145	240	39	2	1	0.880	1
Adherence to industry standards	165	212	36	6	0	0.864	2
Educational initiatives	180	188	42	6	1	0.860	3
Collaboration with local communities	160	204	42	8	0	0.854	4
Regulations and policies	140	236	24	10	2	0.849	5
The values and attitudes of the workforce	145	212	45	2	0	0.833	6
Client, investor, and shareholder requirements	180	176	36	4	0	0.816	7

4.6.4 Discussion of findings of key drivers for contractors' waste management practices.

The study used the Relative Importance Index (RII) to evaluate a variety of environment-related factors to analyse the key drivers for contractor's waste management practices. As shown in Table 4.13, the top three factors that respondents selected as important are waste reduction and recycling, water conservation and management, and resource management. Results show that recycling and waste reduction are crucial for managing construction waste in South Africa in an efficient manner. This result is consistent with Mbadugha *et al*. (2021), who noted the importance of recycling and waste reduction strategies in the construction industry. According to research by Esa *et al*. (2017), implementing waste reduction and recycling programmes can dramatically reduce the environmental impact of construction activities while simultaneously lowering costs and encouraging sustainability. Among South African contractors, water conservation and management stand out as another essential factor of waste management strategies. This result is in line with Ajayi *et al*. (2016) who highlighted the necessity of water-efficient construction approaches to reduce the negative environmental effects of construction operations and address concerns about water scarcity. Waste management practices among contractors are found to be significantly influenced by resource efficiency. Resources-efficient construction practices have a critical role in cutting material consumption, lowering waste creation, and improving project sustainability (Ajayi *et al*., 2016). Cheng *et al*. (2022) highlighted the possible advantages of implementing resource-efficient methods, including lean construction principles, to increase project efficiency and sustainability.

The top three economical related factors driving contractors' waste management practices include recycling opportunities, material costs, and regulatory compliance costs which are rated by the respondents as indicated in Table 4.14. The analysis shows that among South African contractors, recycling opportunities are thought to be the most important economic factor driving waste management practices. This is supported by Shooshtarian *et al*. (2020) who pointed out that recycling construction waste can save natural resources and drastically lower disposal costs. Ezeah *et al*. (2013) further support this by emphasising that recycling activities can save money and support sustainable construction practices. The second most significant cost factor driving contractor's waste management strategies is the cost of materials. This result is in line with a study by Nyika *et al*. (2019), who found that to keep project budgets and profitability intact, effective material management and waste reduction measures are required due to the growing cost of building materials. Furthermore, a study by Musarat *et al*. (2021) emphasises the impact of material waste on building costs and the necessity of efficient waste management techniques to limit material losses and lower project costs overall.

The results presented in Table 4.15 show that public awareness is the most important social factor driving waste management practices among South African contractors. This finding is consistent with Fei *et al*. (2021), who noted that more community involvement and support for waste reduction programmes can result from raising public understanding of the negative environmental effects of construction waste. In addition, the study by Udawatta *et al*. (2015) emphasises how public awareness campaigns can successfully alter attitudes and behaviours about waste management, resulting in the adoption of more environmentally friendly methods in the construction industry. The second most significant social component is found to be adherence to industry standards, highlighting the importance of following set rules and best practices in waste management. This result is consistent with research by Esa *et al.* (2017), who emphasise the value of industry standards in guaranteeing uniform and efficient waste management practices. Educational initiatives were ranked third. This result aligns with the findings of Dosumu and Aigbavboa (2021), who noted that education can help construction personnel become more knowledgeable and skilled so they can apply waste management practices that are more effective. The study of Kabirifar *et al*. (2020) also shows that ongoing instruction and training can increase construction workers' and managers' awareness of and implementation of sustainable practices.

4.7 Challenges experienced by contractors related to reduction of construction waste

4.7.1 Challenges experienced by contractors related to reduction of construction waste

Table 4.16 presents the results with regards to challenges experienced by contractors related to reduction of construction waste. The respondents were asked to indicate the level of agreement using a 5-point scale: Strongly Disagree, Disagree, Moderate, Agree, Strongly Agree and Unsure. 'Absence of waste reduction plans' was ranked first with (MV=4.26). A noteworthy 81.9% of respondents agreed that the absence of structured waste reduction plans is a significant challenge. Additionally, 12.4% indicated a moderate level of agreement. On the other hand, 2.9% of respondents disagreed, suggesting a minority perspective, while 2.8% were unsure. Lack of education about waste reduction was ranked second, with (MV=4.24) and 81% of the respondents agreed that lack of education on waste reduction is a significant obstacle. Meanwhile, 16.2% held a moderate position, indicating a potential need for more targeted educational initiatives. Conversely, 2% disagreed and a mere 0.8% were unsure. Ranked third is 'Lack of awareness about waste reduction' with (MV=4.23). An overwhelming 81.0% of respondents agreed that a lack of awareness about waste reduction poses a substantial challenge, 14.3% of respondents were moderate, while 2% of respondents disagreed with this perspective, and about 2.7% of respondents were unsure. It is evident from the results that the lowest ranked is 'Fear of project delays due to waste reduction initiatives', with (MV=3.82) and 69.5% of respondents agreeing that there is a legitimate concern about project delays associated with waste reduction initiatives, 14.3% of respondents were moderate, 10.5% of respondents disagreed, and about 5.7% of respondents were unsure. The average mean value for the combined factors is 4.08, and it is noteworthy to emphasise that all mean values are higher than 3.00.

Table 4.16 Challenges experienced by contractors

Challenges experienced by contractors	**Frequency**	**Unsure**	**Strongly Disagree**	**Disagree**	**Moderate**	**Agree**	**Strongly Agree**	**Mean**	**Std.**	**Rank**
Absence of waste reduction plans	105	2.8	1.0	1.9	12.4	37.1	44.8	4.26	.832	1
Lack of education about waste reduction	105	0.8	1.0	1.0	16.2	36.2	44.8	4.24	.830	2
Lack of awareness about waste reduction	105	2.7	1.0	1.0	14.3	40.0	41.0	4.23	.807	3
Lack of comprehensive waste management plan	105	3.9	0.0	1.9	11.4	45.7	37.1	4.23	.733	3

Lack of on-site recycling facilities	105	1.9	0.0	5.7	8.6	43.8	40.0	4.20	.833	4
Lack of sustainable procurement strategies	105	9.5	0.0	1.9	12.4	41.9	34.3	4.20	.752	4
Improper waste segregation	105	8.6	0.0	1.9	14.3	41.9	33.3	4.17	.763	5
Ineffective communication regarding waste reduction	105	3.9	0.0	3.8	11.4	47.6	33.3	4.15	.780	6
Contractors focus on production rather than waste reduction	105	2.9	1.9	3.8	10.5	43.8	37.1	4.14	.901	7
Implementation of lean construction principles	105	8.6	0.0	1.9	16.2	41.9	31.4	4.13	.771	8
Limited space for on-site waste sorting and storage	105	4.8	1.0	4.8	15.2	35.2	39.0	4.12	.924	9
Lack of training for contractors and workers	105	0.0	0.0	4.8	16.2	41.9	37.1	4.11	.847	10
Ineffective systems for waste tracking and reporting	105	2.8	1.0	3.8	12.4	46.7	33.3	4.11	.843	10
Lack of clear waste reduction goals and targets	105	4.7	1.0	2.9	14.3	43.8	33.3	4.11	.840	10
Inadequate waste audits to assess types and quantities	105	4.8	1.9	2.9	11.4	47.6	31.4	4.09	.866	11
Source separation of waste	105	3.8	1.9	2.9	16.2	40.0	35.2	4.08	.913	12
Contractors face cost-related hurdles when implementing waste reduction measures	105	2.8	1.0	0.0	18.1	50.5	27.6	4.07	.748	13
Facing difficulties in tracking waste on site	105	2.7	1.0	6.7	12.4	42.9	34.3	4.06	.921	14
Limited space for waste storage	105	1.9	3.8	2.9	12.4	43.8	35.2	4.06	.978	14
Disregard for sustainability practices	105	9.5	1.9	1.0	13.3	47.6	26.7	4.06	.823	14
Identification of nearby recycling facilities	105	3.7	1.0	1.0	18.1	48.6	27.6	4.05	.779	15
Lack of contractors' integrated waste management system	105	5.7	1.0	1.9	19.0	42.9	29.5	4.04	.832	16
Improper reuse of materials on-site	105	1.9	1.0	4.8	13.3	51.4	27.6	4.02	.840	17
Choosing material without thorough thinking	105	1.9	1.0	7.6	18.1	37.1	34.3	3.98	.970	18
The use of inadequate equipment	105	4.8	0.0	7.6	15.2	43.8	28.6	3.98	.887	18
Unclear responsibilities for waste management in construction work site	105	2.9	1.0	3.8	17.1	49.5	25.7	3.98	.832	18
Limited access to recycling facilities	105	2.9	1.9	6.7	15.2	43.8	29.5	3.95	.958	19
Consideration of deconstruction when appropriate	105	10.4	1.0	8.6	13.3	41.9	24.8	3.90	.951	20

There is no zero-waste culture in the construction worksite	105	2.7	4.8	6.7	14.3	41.0	30.5	3.88	1.084	21
Fear of project delays due to waste reduction initiatives	105	5.7	3.8	6.7	14.3	47.6	21.9	3.82	1.004	22
Average	**105**							**4.08**		

4.7.2 Exploratory Factor Analysis

7.2.1 Challenges experienced by contractors related to reduction of construction waste

This study employed EFA to identify and group the challenges contractors encounter in reducing construction waste on-site. A total of 30 variables were analyzed to uncover the primary obstacles affecting contractors' ability to manage and minimize waste effectively. EFA was chosen due to its suitability for analyzing complex, multidimensional constructs, such as waste reduction challenges, which often involve interconnected issues. Through this method, the study organized these variables into manageable components, highlighting the most significant challenges contractors face. Additionally, EFA enhanced the consistency of the quantitative analysis by reducing the dataset's dimensionality. This approach identified underlying patterns or latent variables influencing contractors' challenges, rather than analyzing individual variables in isolation. PCA was further utilized to pinpoint the key contributors to these challenges, providing deeper insights into the factors that most significantly impact contractors' waste reduction efforts. By extracting the most meaningful components from the data, PCA ensured that the findings were both robust and reliable.

Table 4.17 presents the analysis of obtained data concerning challenges experienced by contractors related to reduction of construction waste, showed that the sample was judged suitable for factor analysis because the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.834, which is higher than 0.60. Additionally, the corresponding significance level was 0.001 and the Bartlett test of sphericity was 1631.370.

Table 4.17 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.834
Bartlett's Test of Sphericity	Approx. Chi-Square	1631.370
	,Df	435
	Sig.	001

The utilisation of PCA in examining 30 challenges experienced by contractors related to reduction of construction waste in construction sites. Thus, a total of seven latent factors were extraction with eigenvalues greater than 1.0. Table 4.18 presented eigenvalues of the extracted components as 13.791, 1.739, 1.378, 1.316, 1.232, 1.165 and 1.091, thus explaining 72.37% of the variance.

Table 4.18 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.791	45.972	45.972	13.791	45.972	45.972
2	1.739	5.795	51.767	1.739	5.795	51.767
3	1.378	4.594	56.360	1.378	4.594	56.360
4	1.316	4.388	60.749	1.316	4.388	60.749
5	1.232	4.108	64.857	1.232	4.108	64.857
6	1.165	3.882	68.739	1.165	3.882	68.739
7	1.091	3.635	72.374	1.091	3.635	72.374
8	.946	3.152	75.526			
9	.741	2.469	77.995			
10	.685	2.282	80.277			
11	.656	2.186	82.463			
12	.599	1.998	84.462			
13	.588	1.961	86.422			
14	.476	1.587	88.010			
15	.438	1.460	89.469			
16	.430	1.434	90.903			
17	.390	1.300	92.203			
18	.358	1.195	93.398			
19	.303	1.010	94.408			
20	.294	.979	95.387			
21	.271	.904	96.291			
22	.228	.759	97.050			
23	.208	.693	97.743			
24	.174	.581	98.325			
25	.137	.458	98.783			

26	.118	.392	99.174			
27	.081	.269	99.444			
28	.066	.220	99.664			
29	.059	.197	99.861			
30	.042	.139	100.000			
Extraction Method: Principal Component Analysis.						

Each of the 7 components identified by the study in Tables 4.18 and 4.19 represents a major challenge that contractors face on construction sites. The analysis was limited to the most pertinent factors by excluding any variables with factor loadings less than 0.30. Component 1, "ineffective communication regarding waste reduction", highlights the effects of inadequate communication and the lack of a unified waste management approach. It includes variables such as "ineffective communication regarding waste reduction" and "lack of contractors' integrated waste management system". Effective waste reduction efforts are severely hampered by these variables. Component 2 “Limited access to recycling facilities” emphasizes the real-world challenges contractors encounter while looking for suitable recycling solutions. According to variables like "Limited access to recycling facilities" and "Identification of nearby recycling facilities", the absence of easily accessible recycling facilities severely impedes contractors' attempts to divert waste from landfills. Component 3, "Improper Reuse of Materials On-Site" deals with the difficulties that arise when materials are recycled and reused on-site. Inefficient material reuse procedures hinder effective waste management, as evidenced by factors such as "Improper reuse of materials on-site" and "Consideration of deconstruction when appropriate". Component 4, "lack of a zero-waste culture on the worksite", reflects the cultural obstacles to waste reduction in the construction industry. Variables such as "there is no zero-waste culture in the construction worksite" and "facing difficulties in tracking waste on-site" show that a lack of commitment to waste reduction and inefficient waste tracking systems contribute to the overall challenges. Component 5, "identification of nearby recycling facilities" highlights the difficulty contractors face in locating suitable recycling facilities, which is essential for successful waste diversion. Variables like "identification of nearby recycling facilities" and "fear of project delays due to waste reduction initiatives" reveal concerns about potential delays and the scarcity of recycling options. Component 6, "use of inadequate equipment" points to the absence of proper equipment needed for effective waste management. Variables such as "the use of inadequate equipment" and "lack of contractors’ integrated waste management system" suggest that insufficient resources and systems further hinder the proper handling of waste. Lastly, component 7 variables like "facing difficulties in tracking waste on-site" and "ineffective systems for waste tracking and reporting" emphasize the need for efficient tracking systems, which are often lacking on many construction sites.

Table 4.19 Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
C1 Ineffective communication regarding waste reduction	.800						
Lack of contractors' integrated waste management system	.799						
Improper waste segregation	.779						
Lack of sustainable procurement strategies	.772						
Contractors focus on production rather than waste reduction	.766						
Limited space for on-site waste sorting and storage	.763						
Contractors face cost-related hurdles when implementing waste reduction measures	.759						
Implementation of lean construction principles	.747						
Lack of education about waste reduction	.735						
Lack of comprehensive waste management plan	.734						
Lack of awareness about waste reduction	.733						
Absence of waste reduction plans	.711						
Ineffective systems for waste tracking and reporting	.696						
Lack of training for contractors and workers	.691						
Lack of on-site recycling facilities	.684						
The use of Inadequate equipment	.684						
Improper reuse of materials on-site	.683						
Inadequate waste audits to assess types and quantities	.671						
Lack of clear waste reduction goals and targets	.665						
Limited space for waste storage	.662						
Consideration of deconstruction when appropriate	.662						
Disregard for sustainability practices	.640						
Source separation of waste	.615						
Choosing material without thorough thinking	.587						
Identification of nearby recycling facilities	.576						
Limited access to recycling facilities	.552						

Fear of project delays due to waste reduction initiatives	.542						
Facing difficulties in tracking waste on site	.525						
Unclear responsibilities for waste management in construction work site	.478						
There is no zero-waste culture in the construction worksite	.427						
C2 Limited access to recycling facilities		.527					
There is no zero-waste culture in the construction worksite		.493					
Lack of clear waste reduction goals and targets		.447					
Limited space for waste storage		.436					
Unclear responsibilities for waste management in construction work site		.377					
Improper waste segregation		.301					
C3 Improper reuse of materials on-site			.415				
Consideration of deconstruction when appropriate			.397				
Identification of nearby recycling facilities			.376				
Absence of waste reduction plans			.348				
Source separation of waste			.306				
C4 There is no zero-waste culture in the construction worksite				.508			
Facing difficulties in tracking waste on-site				.377			
Unclear responsibilities for waste management in the construction worksite				.369			
Choosing material without thorough thinking				.352			
Lack of awareness about waste reduction				.301			
C5 Identification of nearby recycling facilities					.454		
Fear of project delays due to waste reduction initiatives					.334		
Facing difficulties in tracking waste on site					.306		
Source separation of waste					.303		
C6 The use of inadequate equipment						.468	
Disregard for sustainability practices						.330	
Lack of contractors' integrated waste management system						.314	
Lack of sustainable procurement strategies						.312	
C6 Facing difficulties in tracking waste on site							.502

Consideration of deconstruction when appropriate							.345
Ineffective systems for waste tracking and reporting							.371
Lack of on-site recycling facilities							.303
Lack of training for contractors and workers							.303
Extraction Method: Principal Component Analysis.							
a. 7 components extracted.							

4.7.3 Discussions of findings of challenges experienced by contractors regarding the reduction of construction waste

The highest rating (MV=4.26) went to the lack of waste reduction plans. The findings of Udawatta *et al.* (2015) support this conclusion by highlighting the inefficiencies and increased waste creation that come from the lack of waste reduction plans on construction projects. This conclusion is reinforced further by Darko *et al*. (2017), who corroborate the difficulties contractors encounter when their projects lack comprehensive waste reduction measures. Table 4.16 presents the findings, which show that inadequate education about waste reduction with (MV=4.24) was the most significant challenge experienced by contractors related to reduction of construction waste. This is corroborated by the research of Polat *et al*. (2017), which emphasised the negative effects of insufficient training and education on contractors' capacity to apply environmentally friendly waste reduction practices. Polat *et al*. (2017) further promoted expanded contractor education to improve waste management practices. Both the lack of awareness about waste reduction and lack of comprehensive waste management plan were ranked as the third most important challenge, with (MV=4.23). This in line with the findings by Hasmori *et al*. (2020) who found that the primary obstacle facing the construction industry is the lack of awareness among local contractors, construction workers and architects about waste management practices. Dosumu and Aigbavboa (2021) emphasised the significance of increasing awareness through conferences, professional associations, and educational institutions to promote and strengthen the use of sustainable construction techniques. On the other hand, findings by Nyika *et al*. (2019) revealed that in most construction sites there is no waste management plan. Ferronato and Torretta (2019) add that management plans are all necessary procedures for enhancing a nation, region, municipality, or rural area's integrated waste management system.

Component 1: Ineffective communication regarding waste reduction

Ineffective communication regarding waste reduction (.800), lack of contractors' integrated waste management system (.799), improper waste segregation (.779), lack of sustainable procurement strategies (.772), contractors focus on production rather than waste reduction (.766), limited space for on-site waste sorting and storage (.763), contractors face cost-related hurdles when implementing waste reduction measures (.759), implementation of lean construction principles (.747), lack of education about waste reduction (.735), lack of comprehensive waste management plan (.734), lack of awareness about waste reduction (.733), absence of waste reduction plans (.711), ineffective systems for waste tracking and reporting (.696), lack of training for contractors and workers (.691), lack of on-site recycling facilities (.684), the use of inadequate equipment (.684), improper reuse of materials on-site (.683), inadequate waste audits to assess types and quantities (.671), lack of clear waste reduction goals and targets (.665), limited space for waste storage (.662), consideration of deconstruction when appropriate (.662), disregard for sustainability practices (.640), source separation of waste (.615), choosing material without thorough thinking (.587), identification of nearby recycling facilities (.576), limited access to recycling facilities (.552), fear of project delays due to waste reduction initiatives (.542), facing difficulties in tracking waste on-site (.525), unclear responsibilities for waste management in construction worksite (.478), there is no zero-waste culture in the construction worksite (.427).

In the construction industry, one of the biggest obstacles to attaining sustainable waste management is inadequate communication regarding waste reduction. Onamade et al. (2022) assert that good communication is necessary to guarantee that all stakeholders are informed about and in favour of waste reduction initiatives. Regular feedback loops are also crucial, as noted by Udawatta *et al*. (2015), for updating waste reduction plans based on real-world data and experience. The absence of clear waste reduction goals and targets can lead to inconsistent efforts and inadequate waste control techniques. Mbadugha *et al*. (2021) found that precise waste reduction goals are essential for guiding the actions of all parties involved in construction projects. Similarly, van Rensburg (2022) highlights the importance of specific goals in improving waste management effectiveness. Hasmori *et al*. (2020) and Zhao (2021) further emphasise that a lack of planning and communication can result in increased waste production and reduced waste management efforts.

The lack of an integrated waste management system among contractors poses another significant challenge. Ajayi and Oyedele (2018) state that it is challenging to regularly implement efficient waste reduction strategies in the lack of a comprehensive system. Additionally, Ferronato and

Torretta (2019) emphasise that enhancing efficiency and guaranteeing the constant application of waste reduction techniques require an integrated system. Improper waste segregation is another critical issue. Hasmori *et al*. (2020) note that inadequate training and understanding of segregation processes can lead to contaminated recyclable materials and increased landfill waste. Onamade *et al*. (2022) further stress that improper waste segregation is frequently the consequence of inadequate understanding of waste management strategies, which lowers the efficacy of recycling operations. A contributing factor to the issue is the absence of sustainable procurement practices in the construction industry. According to Mirtl *et al*. (2018), adopting sustainable procurement methods requires explicit policy requirements.

Hung and Kamaludin (2017) highlight that procurement experts' ignorance of sustainable solutions complicates the issue, underscoring the need for educational initiatives. Contractors’ focus on production deadlines rather than waste reduction often results in increased waste. Nyika *et al*. (2019) note that prioritising production can lead to missed opportunities for sustainability, while Nagapan *et al*. (2012) emphasise the need to balance productivity with environmental goals. Limited space for on-site waste sorting and storage further complicates effective waste management. Onamade *et al*. (2022) point out that inadequate space makes it difficult to implement effective waste sorting techniques, leading to increased waste and inefficiencies. Bajjou *et al*. (2017) suggest that meticulous planning and optimisation of space are necessary to manage waste effectively, even in constrained environments. Financial obstacles also pose significant challenges to waste reduction. Ajayi and Oyedele (2018) discuss the necessity of affordable solutions and highlight the financial challenges involved. Udawatta *et al*. (2015) emphasise the importance of demonstrating the long-term financial benefits of waste reduction to overcome these cost-related hurdles.

The implementation of lean construction principles requires effective communication and training. Howell and Koskela (2000) stress that successful adoption depends on the appropriate sharing of knowledge and ongoing communication among all parties. Mbadugha *et al*. (2021) support this by noting that lean concepts can reduce waste but require efficient communication routes for correct application. Education plays a crucial role in improving waste management practices. Zhao (2021) highlights the importance of frequent training sessions to enhance employees' proficiency in waste management, while Polat *et al*. (2017) emphasises the need for ongoing education to ensure staff are knowledgeable about best practices and can support waste reduction initiatives. A comprehensive waste management plan is essential for effective waste reduction. Van Wyk (2014) highlights that without a well-defined plan, waste reduction efforts can be arbitrary and ineffective. Furthermore, Hasmori *et al*. (2020) note that inefficiencies and increased waste on construction sites can arise from a lack of such planning. Effective implementation of waste reduction requires raising awareness of the issue. Yuan (2017) emphasises that management must ensure employees understand the significance of waste reduction and communicate this message effectively. Ajayi *et al.* (2015) argue that organised training programmes and accessible educational materials are essential for equipping workers with the necessary information and skills.

The absence of waste reduction plans often leads to inefficiencies and increased waste. Hasmori *et al.* (2020) highlight that the lack of planning can result in higher waste generation on construction sites. Mbadugha *et al*. (2021) note that poor waste management techniques may stem from ignorance or misinterpretation of equipment requirements and uses. Effective systems for waste tracking and reporting are crucial for accurate monitoring. Liwan *et al*. (2013) emphasise the challenges in waste tracking and the need for precise data collection and analysis. Zorpas (2020) stresses the importance of having strong communication systems to maintain accurate records and ensure accountability in waste management procedures. Training is essential for improving waste management practices. Zorpas (2020) emphasises that accurate planning and communication are necessary for effective deconstruction, and that both can be assisted by appropriate training. Ajayi *et al*. (2015) emphasise the significance of continual education to guarantee that staff members are informed about best practices. Facilities for on-site recycling are essential for reducing waste sent to landfills. While Ghaffar *et al*. (2020) stress that good planning and communication are necessary to incorporate recycling facilities into project settings. Kang *et al.* (2022) point out that these facilities help reduce waste going to landfills.

The use of appropriate equipment is vital for effective waste management. Sev (2009) highlights the need for suitable tools and apparatus to manage waste efficiently, while inadequate equipment can lead to inefficiencies and increased waste on construction sites. Improper reuse of materials can contribute to increased waste and safety issues. Mohan *et al*. (2015) argues that unclear rules and procedures regarding material reuse contribute to these problems, and Abarca-Guerrero *et al.* (2017) stress the importance of training and clear communication to ensure materials are reused appropriately, reducing waste and enhancing on-site safety. Inadequate waste audits hinder effective waste management. Durdyev *et al.* (2018) highlight that waste audits provide vital data for organising and implementing waste reduction strategies. While Abdel-Shafy and Mansour (2018) emphasise the importance of waste audits in identifying areas where waste can be reduced. Clear waste reduction goals and targets are essential for guiding waste management efforts. Zhao (2021) emphasises that thorough planning enhances waste management efforts. Chidiobi (2022) underscores that clear goals are crucial for effective waste reduction, helping to direct the activities of all parties involved.

Limited space for waste storage affects waste management efficiency. Abubakar *et al*. (2022) discuss how spatial constraints impact waste storage and management. While Yuan (2017) suggests that better planning can streamline waste management procedures and maximise storage options. Considering deconstruction methods can enhance sustainability in construction projects, Zorpas (2020) highlights the importance of planning for deconstruction to maximise its benefits. Bao and Lu (2021) stress that informing stakeholders about the advantages of deconstruction and incorporating it into project design is essential. Disregard for sustainability practices can lead to inefficiencies and increased waste. Durdyev *et al*. (2018) point out that a lack of attention to sustainability efforts can result in increased waste. Coskun (2022) emphasises the need for a deliberate effort to promote the benefits and methods of waste reduction to establish a zero-waste culture. Effective source separation of waste depends on clear instructions and communication. Gamil and Rahman (2021) highlight that poor communication can lead to incorrect waste separation, reducing recycling effectiveness.

Choosing materials without thorough consideration can contribute to waste production. Finding recycling facilities in the area is crucial for efficient waste management. Von Blottnitz *et al*. (2022) stress that construction teams need easy access to information about these facilities, and Godfrey and Oelofse (2017) emphasise that utilising nearby recycling facilities helps in managing waste more effectively. Effective waste management is hampered by limited access to recycling facilities. While Onamade *et al*. (2022) emphasise the need for better infrastructure and access to recycling facilities to assist waste management efforts, Bao and Lu (2021) address how limited access effects waste management practices. It is a common concern among contractors that the implementation of waste reduction programmes may cause delays in their projects. Bao *et al*. (2020) explores this fear and its impact on waste management practices. While Li *et al*. (2017) suggests that addressing these fears through effective planning and communication can help mitigate concerns about delays and promote successful waste reduction efforts. Facing difficulties in tracking waste on-site can also impact waste management efficiency. Liwan *et al*. (2013) draw attention to the difficulties associated with waste tracking and the necessity of efficient waste management systems. Ghaffar *et al.* (2020) stress that these difficulties can be overcome by implementing precise tracking mechanisms and fostering robust communication to guarantee accurate waste monitoring. Inefficiencies and poor management might result from unclear roles in waste management. Polat *et al*. (2017) stress that a clear division of labour contributes to appropriate waste management procedures and accountability on construction sites. Durdyev *et al*. (2018) note that defining roles and responsibilities is essential for efficient waste management. Lastly, efficient waste management may be hampered by building sites lacking a zero-waste mentality. Mbadugha *et al*. (2021) emphasise the significance of developing a culture that values sustainability and waste reduction. Whereas Coskun (2022) contends that cultivating a zero-waste culture is crucial for advancing sustainable waste practices.

Component 2: Limited access to recycling facilities

Limited access to recycling facilities (.527), there is no zero-waste culture in the construction worksite (.493), limited space for waste storage (.436), lack of clear waste reduction goals and targets (.447), unclear responsibilities for waste management in construction work site (.377), improper waste segregation (.301).

In the construction industry, limited access to recycling facilities is a significant challenge, as noted by Darko *et al*. (2017), who argue that contractors may be discouraged from recycling if facilities are not easily accessible, leading to higher transportation costs and reduced recycling efforts. Bao *et al*. (2020) suggests that on-site recycling capabilities, such as mobile recycling machines, can facilitate waste processing directly at the construction site, thereby promoting recycling and reducing transportation expenses. Another major issue is the lack of a zero-waste culture on construction sites. Zaman and Lehmann (2011) highlight that the focus on project completion often overshadows efforts towards sustainable waste management. Van Wyk (2014) adds that perceived high costs and time constraints associated with sustainable practices contribute to this absence of a zero-waste culture.

Space constraints on construction sites further complicate waste management, as it becomes challenging to store separated waste materials properly. Nawaz *et al*. (2023) recommend careful planning and design of waste storage areas to address this issue. Azzi (2017) offers a solution through creative approaches like compactors and vertical storage systems, which can help manage waste effectively even in limited space. The lack of clear waste reduction goals and targets impedes effective waste management. Durdyev *et al*. (2018) highlight that without clear and quantifiable targets, contractors and construction managers often lack the motivation and guidance to implement efficient waste management practices. Ajayi and Oyedele (2018) support this by noting that inadequate enforcement and infrequent monitoring can lead to poor implementation, even when waste reduction targets are established.

Unclear responsibilities for waste management contribute to ineffective practices. Park and Tucker (2017) emphasise that clearly defining roles and duties is essential for ensuring accountability and effective implementation of waste management policies, including overseeing recycling, transportation, and waste segregation. Another major problem is improper waste segregation. According to Abubakar *et al*. (2022), effective source segregation is crucial for both recycling and waste reduction. On the other hand, incorrect segregation may result from poor infrastructure, such as a lack of designated containers or inadequate training. This leads to higher volumes of mixed waste, which are harder to recycle (Tafesse *et al*., 2022).

Component 3: Improper reuse of materials on-site

Improper reuse of materials on-site (.415), consideration of deconstruction when appropriate (.397), identification of nearby recycling facilities (.376), absence of waste reduction plans (.348), source separation of waste (.306).

Tam *et al*. (2018) have observed that inappropriate reuse of materials on-site can be linked to a lack of understanding of appropriate repurposing procedures. Tam *et al*. (2018) contends that a lack of information about successful repurposing frequently leads to improper reuse. Darko *et al*. (2017) provide additional support for this by highlighting the connection between inadequate waste reduction methods and inappropriate material reuse. Darko *et al*. (2017) propose that complete waste reduction plans that incorporate material reuse approaches are essential for appropriate on-site waste management. Consideration of deconstruction when appropriate also plays a critical role. Bao and Lu (2021) highlight that deconstruction can significantly reduce waste and promote on-site material reuse compared to conventional destruction methods. However, Liu *et al*. (2020) caution that deconstruction can be more costly and time-consuming. The identification of nearby recycling facilities is another important factor. Ajayi *et al*. (2016) argue that accessible recycling facilities make it easier to process and reuse materials on-site, thus reducing overall waste, while Zaman *et al.* (2020) point out that these facilities encourage immediate reuse by eliminating the need for off-site transportation. The absence of waste reduction plans can lead to inadequate material reuse strategies. Hasmori *et al*. (2020) contend that having comprehensive waste reduction plans is essential for significant waste reductions, and these plans require ongoing monitoring and adjustments to be effective. Lastly, source separation of waste is a crucial factor. Abubakar *et al*. (2022) observe that improper sorting of waste at the source complicates the identification of recyclable materials, increasing the volume of waste sent to landfills. Tafesse *et al*. (2022) argue that improved source separation can enhance the potential for on-site material reuse.

Component 4: There is no zero-waste culture in the construction worksite

There is no zero-waste culture in the construction worksite (.508), facing difficulties in tracking waste on-site (.377), unclear responsibilities for waste management in the construction worksite (.369), choosing material without thorough thinking (.352), and lack of awareness about waste reduction (.301).

The construction worksite often struggles with the absence of a zero-waste culture. Reducing waste, reusing, and recycling are the goals of a zero-waste culture, which takes a comprehensive strategy with commitment from all stakeholders. According to Zaman and Lehmann (2011), policies and top-down leadership are necessary to establish a zero-waste culture. The development of a zero-waste culture is significantly hampered by managers' and employees' ignorance about the significance and techniques of waste reduction. To increase knowledge and support sustainable behaviours, education and training initiatives are crucial (Ajayi *et al*., 2015). Determining the sources of waste and putting reduction plans into action depend on efficient waste tracking systems. Liwan *et al*. (2013) reveal that efforts to reduce waste are hampered by the fact that many construction sites lack the equipment and technology required for precise waste tracking. Yuan (2017) highlighted that to make sure that waste tracking systems are used efficiently, training and ongoing monitoring are required. Ineffective waste management techniques are the result of unclear waste management responsibilities, which also cause a lack of accountability. Van Wyk (2014) states that to guarantee efficient waste management, roles and responsibilities must be clearly defined. When materials are chosen without taking the environment into account, too much waste is produced. Contractors frequently put cost and availability ahead of sustainability, which leads to the choice of materials that are challenging to recycle or reuse (Purchase *et al*., 2021). Durdyev *et al.* (2018) contend that a lack of knowledge about sustainable alternatives is the cause of the carelessness in material selection. Jaillon *et al*. (2009) noted that contractors and employees are motivated to implement sustainable practices when there is clear financial benefit. The development of a zero-waste culture is significantly hampered by managers' and employees' ignorance about the significance and techniques of waste reduction. To increase knowledge and support sustainable behaviours, education and training initiatives are crucial (Ajayi *et al*., 2015). Gamil and Rahman (2021) reveal that effective waste management requires ongoing assistance and resource allocation.

Component 5: Identification of nearby recycling facilities

The identification of nearby recycling facilities (.454), the fear of project delays due to waste reduction initiatives (.334), facing difficulties in tracking waste on site (.306), the source separation of waste (.303).

For contractors to recycle materials instead of disposing of them incorrectly, proximity to recycling facilities is essential for timely and economical recycling of construction waste (Gharfalkar *et al*., 2015). Portny and Portny (2022) argue that due to space restrictions and a lack of designated bins, source separation can be difficult on busy construction sites. To efficiently manage and minimise waste, accurate on-site waste tracking is required. Regular audits and assessments can aid in more efficiently tracking waste (Yuan, 2017). Liwan *et al*. (2013) noted that construction sites can identify areas for improvement and assure compliance with waste reduction goals by frequently examining their waste management methods. According to Ng *et al*. (2018), on-site waste management training programmes that emphasise the advantages and methods of source separation are required. Regular collaboration and communication can guarantee that construction sites are aware of recycling options and requirements (Onamade *et al*., 2022).

Component 6: The use of inadequate equipment

The use of inadequate equipment (.468), disregard for sustainability practices (.330), lack of contractors' integrated waste management system (.314), and lack of sustainable procurement strategies (.312).

The use of inadequate equipment in construction projects results in inefficient handling and processing of waste, increasing waste volumes and project expenses (Ali *et al*., 2010). The environmental impact is exacerbated when insufficient equipment that is not intended for effective waste management is used in disregard of sustainable norms (Galvez-Martos *et al*., 2018). Kabirifar *et al*. (2020) noted that by encouraging the construction industry to adopt sustainable practices and equipment, waste can be reduced, and the environment can be conserved. Kim *et* *al*. (2006) state that to coordinate the use of the proper tools and methods, an integrated waste management system is necessary. Enhancing the efficacy and efficiency of waste management in construction projects requires creating a comprehensive system that combines sustainable practices and contemporary equipment (Meng *et al*., 2021). Kabirifar *et al.* (2020) assert that environmentally friendly purchasing practices are necessary to obtain the proper machinery for effective waste management. Lack of sustainable procurement methods may result in the use of machinery that is inefficient at using energy or managing recyclables, which increases waste and has an adverse effect on the environment (Mulu, 2021). According to Ezeah *et al*. (2013), investing in contemporary technology for sustainable construction methods can be financially beneficial due to the potential for long-term savings through decreased waste disposal costs and enhanced resource efficiency.

Component 7: Facing difficulties in tracking waste on site

Facing difficulties in tracking waste on site (.502), consideration of deconstruction when appropriate (.345), ineffective systems for waste tracking and reporting (.371), lack of on-site recycling facilities (.303), lack of training for contractors and workers (.303).

Contractors face significant difficulties in tracking waste on-site due to ineffective waste monitoring systems, which are essential for reducing waste and improving recycling operations (Tam *et al*., 2018). These inefficient methods limit the ability to identify areas for improvement by generating inaccurate data on waste creation and disposal, which hinders the implementation of effective waste reduction projects (Nawaz *et al.*, 2023). Moreover, the lack of on-site recycling facilities makes these issues worse because waste needs to be carried off-site for recycling, which makes it more difficult to monitor and manage waste streams properly (Abdel-Shafy & Mansour, 2018). Recyclable material sorting and transportation can be logistically challenging, which can result in higher contamination rates and lower recycling efficiency (Kang *et al*., 2022). Compounding these issues is the lack of training for contractors and workers, which is crucial for ensuring they understand the importance of waste tracking and know how to use tracking systems effectively (Nyika *et al*., 2019). Inadequate training can result in incorrect tracking and inappropriate treatment of waste, undermining efforts to reduce waste and increasing the risk of non-compliance with regulations (Kabirifar *et al.,* 2020).

4.8 Construction waste management practices in South Africa

4.8.1 Effective waste management on construction site

Effective waste management on construction sites is presented in Table 4.20. A 5-point scale was used: Very small extent, Small extent, Moderate extent, Large extent, Extremely large extent and Unsure. Materials selection was ranked first with (MV=3.87). A significant 66.6% of respondents expressed a large extent of agreement, indicating a consensus regarding the important role materials selection plays in reducing waste. Additionally, 21.9% of respondents held a moderate extent perspective, 8.6% of respondents conveyed a small extent of agreement, while 2.9% were unsure. Compliance with regulations was ranked second, with (MV=3.69); significantly, 60% of respondents said they agreed with the statement largely highlighting how crucial regulatory compliance is to efficient waste management. A total of 18.1% of respondents had a moderate extent perspective, indicating that they understood the regulatory framework's importance but did not believe it to be the only one. On the other hand, a significant percentage of respondents (36.2%) expressed a small extent of agreement. The percentage of responders who were unsure about this was 0.9%. Conducting regular inspections was ranked third with (MV=3.59). A substantial 54.3% of respondents conveyed that they believe regular inspections play a critical and significant role in ensuring effective waste management practices, while 23.8% of respondents conveyed a moderate extent of agreement and, meanwhile, 19.0% of respondents expressed a small extent of agreement. Furthermore, about 2.9% of respondents were unsure about the effectiveness of conducting regular inspections. Waste audit and baseline assessment was ranked least, with (MV=3.44); 50.5% of the respondents expressed their agreement to a large extent, 22.9% of respondents conveyed a moderate extent of agreement, while it is noteworthy that a sizeable 23.8% of respondents expressed a small extent of agreement, indicating that they believe waste audits and baseline assessments have limited effects on attempts to reduce waste, while 2.8% of respondents were unsure. The respondents' overall opinion of the effectiveness of waste management practices on construction sites is positively reflected by the average MV of the combined components, which is 3.57. It is noteworthy that every MV is higher than 3.00.

Table 4.20 Effective waste management on construction site

Effective waste management on construction site	Frequency	Unsure	Very small extent	Small extent	Moderate extent	Large extent	Extremely large extent	Mean	Std.	Rank
Materials selection	105	2.9	1.0	7.6	21.9	39.0	27.6	3.87	.951	1

Compliance with regulations	105	0.9	2.9	18.1	18.1	27.6	32.4	3.69	1.191	2
Conduct regular inspections	105	2.9	5.7	13.3	23.8	26.7	27.6	3.59	1.205	3
Management training and awareness	105	1.9	5.7	13.3	24.8	26.7	27.6	3.58	1.201	4
Waste minimisation strategies	105	0.0	3.8	14.3	26.7	31.4	23.8	3.57	1.117	5
Post-construction waste assessment	105	3.7	6.7	16.2	14.3	36.2	22.9	3.54	1.221	6
Waste reduction goals and objectives	105	3.8	2.9	13.3	30.5	32.4	17.1	3.50	1.036	7
Waste tracking and reporting	105	1.9	6.7	20.0	15.2	32.4	23.8	3.48	1.251	8
On-site sorting and recycling	105	4.8	4.8	15.2	29.5	21.9	23.8	3.47	1.176	9
Waste audit and baseline assessment	105	2.8	3.8	20.0	22.9	30.5	20.0	3.44	1.148	10
Average	**105**							**3.57**		

4.8.2 Procurement

The results are shown in Table 4.21 with reference to procurement; the respondents were asked to indicate the level of agreement using a 5-point scale: Very small extent, Small extent, Moderate extent, Large extent, Extremely large extent and Unsure. Rigorous quality assurance to meet project specifications and reduce rework was ranked first with (MV=3.72). A substantial 55.3% of respondents affirmed a large extent of agreement, indicating that this strategy is widely thought to be effective. Additionally, 31.4% of respondents held a moderate extent perspective; meanwhile, 9.6% of respondents expressed a small extent of agreement, and only 3.7% were unsure. ‘Collaboration with like-minded suppliers to encourage reusable and minimal packaging’ and ‘Inventory management to meet project specifications and reduce rework’ were ranked second with (MV=3.70) for both practices. A substantial 70% of respondents expressed a large extent of agreement, showing broad agreement about the need for encouraging cooperation with suppliers who have a similar dedication to sustainability. Additionally, 22.9% of respondents were moderate. On the other hand, 16.2% of respondents expressed a small extent of agreement, and a minimal 0.9% of respondents were unsure. Similarly, for 'Inventory management to meet project specifications and reduce rework’, 59.1% of respondents conveyed a large extent of agreement, highlighting the importance of efficient inventory management in meeting project specifications and minimising rework. A substantial 21.9% held a moderate extent, while 13.4% expressed a small extent of agreement while about 5.6% of respondents were unsure. Similarly, 59.1% of respondents conveyed a large extent of agreement with the statement, "Inventory management to meet project specifications and reduce rework," emphasising the significance of effective inventory management in fulfilling project specifications and reducing rework. Significantly, 21.9% of respondents agreed to a moderate extent, about 13.4% of respondents expressed a small extent of agreement while 5.6% of respondents were unsure. Local sourcing to minimise transport-related waste and emission was ranked third with (MV=3.69). A significant 60% of respondents expressed a large extent of agreement, affirming the importance of minimising environmental impact through local sourcing, and 24.8% of respondents expressed a moderate extent of agreement. Only 11.4% of respondents expressed a small extent of agreement and 3.8% of respondents were unsure. Prioritising practices like just-in-time delivery were ranked least with (MV=3.56); 52.4% of respondents expressed a large extent of agreement, a notable 24.8% of respondents held a moderate extent, and 19.1% of respondents expressed a small extent of agreement. Only 3.7% were unsure about the significance of just-in-time delivery practices. The respondents' overall opinion of the procurement practices at construction sites is positively reflected by the average MV of the combined components, which is 3.66. It is noteworthy that every MV is higher than 3.00.

Table 4.21 Procurement

Procurement	**Frequency**	**Unsure**	**Very small extent**	**Small extent**	**Moderate extent**	**Large extent**	**Extremely large extent**	**Mean**	**Std.**	**Rank**
Rigorous quality assurance to meet project specifications and reduce rework	105	3.7	2.9	6.7	31.4	28.6	26.7	3.72	1.040	1
Collaboration with like-minded suppliers to encourage reusable and minimal packaging	105	0.9	1.9	14.3	22.9	32.4	27.6	3.70	1.087	2
Inventory management to meet project specifications and reduce rework	105	5.6	1.0	12.4	21.9	38.1	21.0	3.70	.994	2
Local sourcing to minimise transport-related waste and emission	105	3.8	3.8	7.6	24.8	38.1	21.9	3.69	1.037	3
Conducting regular waste audits for continuous process improvement	105	1.0	5.7	8.6	27.6	29.5	27.6	3.65	1.147	4
Bulk purchasing to reduce packages waste and lower overall procurement costs	105	1.9	5.7	9.5	27.6	30.5	24.8	3.60	1.141	5
Prioritising practices like just-in-time delivery	105	3.7	2.9	16.2	24.8	28.6	23.8	3.56	1.126	6
Average	**105**							**3.66**		

4.8.3 Handling

The respondents were asked to indicate their degree of agreement on handling on a 5-point scale: Very small extent, Small extent, Moderate extent, Large extent, Extremely large extent and

Unsure, which is shown in Table 4.22. According to the survey results, training relating to safe material handling was ranked first with (MV=4.00). A significant 66.6% of respondents expressed a large extent of agreement, indicating broad agreement on the importance of training relating to safe material handling. Additionally, 24.8% of respondents had a perspective that was moderate. In contrast, a smaller percentage of respondents 6.7% expressed a small extent of agreement, while just 1.9% were unsure. Ensure materials meet quality standards was also ranked first with (MV=4.00). There is broad consensus about the importance of upholding high standards for construction materials, as seen by the overwhelming 72.3% of respondents who indicated a large extent level of agreement. Moreover, 20.0% of respondents had a moderate extent perspective. However, a smaller percentage of respondents (7.6%) indicated a small extent of agreement, and a negligible 0.1% were unsure. Efficient storage and organisation of materials was also ranked second with (MV=3.85). There is broad understanding regarding the need for structured storage procedures in construction, as seen by the substantial 62.9% of respondents who showed a large extent of agreement. Furthermore, 27.6% of respondents had a moderate extent perspective, indicating that effective storage is important and that this view is widely shared. Conversely, 6.7% of respondents expressed a small extent, while just 2.8% were unsure. Reuse of materials whenever possible was ranked third with (MV=3.85). There is broad consensus regarding the significance of material reuse in construction practices, as seen by the substantial 65.7% of respondents who expressed a large extent of agreement. Furthermore, 20.0% of respondents had a moderate extent perspective, demonstrating that there is general agreement on the importance of recycling materials wherever it is practical. Conversely, 11.4% of respondents indicated a small extent, while 2.9% of respondents were unsure. Source separation of materials was ranked least with (MV=3.52). Nevertheless, a substantial 54.3% of respondents expressed a large extent of agreement, highlighting a noteworthy level of consensus on the importance of separating materials at their source in construction processes. Additionally, 25.7% of respondents held a moderate extent perspective, reflecting a significant acknowledgment of the value of source separation. On the contrary, 18.1% of respondents expressed a more reserved or small extent of agreement, while 1.9% were unsure about the matter. Source separation of materials was ranked least with (MV=3.52). However, a sizable 54.3% of respondents indicated a large extent of agreement regarding the significance of separating materials at the source during the construction process. Furthermore, a notable recognition of the importance of source separation was shown by the moderate extent perspective shared by 25.7% of respondents. Conversely, 18.1% of respondents conveyed a small extent of agreement, whereas 1.9% were unsure regarding the issue. The survey concludes with an overall positive evaluation of the handling practices at construction sites, as reflected by the average (MV=3.78) for the combined components.

Table 4.22 Handling

Handling	Frequency	Unsure	Very small extent	Small extent	Moderate extent	Large extent	Extremely large extent	Mean	Std.	Rank
Training relating to safe material handling	105	1.9	1.0	5.7	24.8	27.6	39.0	4.00	.990	1
Ensure materials meet quality standards	105	0.1	0.0	7.6	20.0	37.1	35.2	4.00	.930	1
Efficient storage and organisation of materials	105	2.8	0.0	6.7	27.6	36.2	26.7	3.85	.905	2
Reuse of materials whenever possible	105	2.9	3.8	7.6	20.0	35.2	30.5	3.83	1.082	3
Enforcing proper material handling techniques to prevent damage and waste	105	1.8	2.9	10.5	24.8	27.6	32.4	3.78	1.111	4
Recycling program for materials like concrete and steel	105	2.8	3.8	10.5	26.7	25.7	30.5	3.71	1.140	5
Detailed waste tracking and record keeping	105	0.9	2.9	14.3	23.8	27.6	30.5	3.69	1.141	6
Ongoing workers training related to material handling procedures	105	1.8	2.9	12.4	26.7	35.2	21.0	3.60	1.051	7
Source separation of materials	105	1.9	4.8	13.3	25.7	34.3	20.0	3.52	1.110	8
Average	**105**							**3.78**		

4.8.4 Operation

In terms of operation, as demonstrated in Table 4.23, respondents were asked to rank their agreement with different claims about efficient waste management on construction sites on a 5-point scale: Very small extent, Small extent, Moderate extent, Large extent, Extremely large extent and Unsure. The survey's results indicate that a significant 68.6% of respondents reported a large extent of agreement, highlighting a consensus within the sample. Additionally, 20.0% of respondents expressed a moderate perspective. In contrast, 11.4%, indicated a small extent of agreement. Remarkably, not a single respondent indicated unsure, indicating a high level of clarity within the surveyed group. Plan construction schedules with time buffers to avoid rushed work was ranked second with (MV=3.91). A substantial majority of respondents, 66.7%, expressed a large extent of agreement, highlighting the consensus regarding the importance of including time buffers in construction schedules. Furthermore, 24.8% of those surveyed had a moderate perspective. Conversely, 6.7% of respondents expressed a small extent of agreement, while 1.8%

of respondents were unsure. Plan construction activities with weather forecasts in mind to minimise work stoppages during adverse conditions was ranked third with (MV=3.90). About 65.7% of respondents expressed a large extent of agreement, indicating that they generally agreed that weather forecasts should be considered when planning building projects. Additionally, 21.0% of respondents had a moderate extent of agreement, recognising the importance of weather-related planning to a lower degree. Merely 1.8% of the respondents indicated uncertainty, whereas 11.5% indicated a small extent of agreement. Minimise rework through accurate project planning and design was ranked least with (MV=3.70). Remarkably, 58.8% of respondents agreed with the statement largely demonstrating a sizeable portion of respondents who recognise the importance of minimising rework through accurate project planning and design. Additionally, a moderate extent of agreement was held by 25.7% of the respondents. However, 15.2% of respondents indicated a small extent of agreement. Notably, just 0.1% of respondents were unsure. The average mean value for the combined factors is 3.84, and it is noteworthy to emphasise that all mean values are higher than 3.00.

Table 4.23 Operation

Operation	**Frequency**	**Unsure**	**Very small extent**	**Small extent**	**Moderate extent**	**Large extent**	**Extremely large extent**	**Mean**	**Std.**	**Rank**
Establish clear communication channels among project operational team	105	0.0	1.9	9.5	20.0	27.6	41.0	3.96	1.082	1
Plan construction schedules with time buffers to avoid rushed work	105	1.8	1.0	5.7	24.8	36.2	30.5	3.91	.940	2
Plan construction activities with weather forecasts in mind to minimize work stoppages during adverse conditions	105	1.8	2.9	8.6	21.0	28.6	37.1	3.90	1.098	3
Provide training to unskilled labour to reduce errors and waste	105	0.1	4.8	9.5	19.0	35.2	31.4	3.79	1.133	4
Minimising variations through accurate project planning and design	105	2.8	1.0	8.6	29.5	31.4	26.7	3.76	.987	5
Minimize rework through accurate project planning and design	105	0.1	5.7	9.5	25.7	27.6	31.4	3.70	1.178	6
Average	**105**							**3.84**		

4.8.5 Culture

Table 4.24 asks respondents to rate their agreement level regarding culture using a 5-point scale: Very small extent, Small extent, Moderate extent, Large extent, Extremely large extent and Unsure. Implement a policy that does not permit any unsafe practices was ranked first with (MV=4.03), a substantial majority, comprising 68.6% of the respondents, who expressed a significant level of agreement with this culture practice. Additionally, 19.0% of the respondents indicated a moderate extent of agreement, while 9.6% conveyed a small extent. A minor proportion of 2.8% of respondents remained unsure about their stance on this cultural aspect. Enforce a zero-tolerance policy for negligence was ranked second, with (MV=4.00). A noteworthy 64.8% of respondents indicated a large extent of agreement, demonstrating the consensus regarding the effectiveness of this strict strategy in encouraging accountability and responsibility. Additionally, 20.0% of respondents expressed a moderate extent of agreement, confirming the policy's strong general popularity. While 10.5% of respondents conveyed a smaller extent of agreement, only 4.7% were unsure. Encourage open communication and value every team member's input was ranked third, with (MV=3.94). Remarkably, 51.4% of the respondents indicated a large extent of agreement with the effectiveness of this approach. Furthermore, 25.7% of respondents indicated a moderate extent of agreement. However, 8.6% of respondents conveyed a smaller extent of agreement, while only 1.9% were unsure about their level of agreement. Gain active involvement and support from senior management was ranked least, with (MV=3.73); a majority of respondents 62.8% expressed a substantially large extent of agreement, emphasising the perceived importance of senior management involvement. Conversely, 21.0% of respondents indicated a moderate extent of agreement, suggesting a more balanced endorsement of the need for senior management engagement, while 15.3% of respondents indicated a small extent of agreement, and about 0.9% of respondents were unsure.

Table 4.24 Culture

Culture	Frequency	Unsure	Very small extent	Small extent	Moderate extent	Large extent	Extremely large extent	Mean	Std.	Rank
Implement a policy that does not permit any unsafe practices	105	2.8	1.0	8.6	19.0	26.7	41.9	4.03	1.038	1
Enforce a zero-tolerance policy for negligence	105	4.7	0.0	10.5	20.0	23.8	41.0	4.00	1.044	2

Encourage open communication and value every team member's input	105	1.9	1.0	7.6	25.7	25.7	38.1	3.94	1.027	3
Create an environment where every worker takes pride in their work and the project's outcomes	105	0.1	1.9	7.6	19.0	39.0	32.4	3.92	.997	4
Implement a strict waste policy with no tolerance	105	2.0	1.9	11.4	18.1	31.4	35.2	3.88	1.087	5
Reward sustainability efforts toward waste reduction through incentives	105	1.9	2.9	14.3	13.3	33.3	34.3	3.83	1.147	6
Invest in ongoing training and skill development	105	1.9	6.7	7.6	23.8	25.7	34.3	3.75	1.210	7
Gain active involvement and support from senior management	105	0.9	2.9	12.4	21.0	35.2	27.6	3.73	1.090	8
Average	**105**							**3.89**		

4.8.6 Discussion of findings of construction waste management practices in South Africa

The findings from Table 4.20 revealed that materials selection was the most significant effective waste management method in construction site practice, with (MV=3.87). This result is consistent with the observation made by Esa *et al*. (2017), who noted that choosing the right material could also aid in lowering waste formation at this point. Mbote *et al*. (2016) stress the importance of making sure that the standards for factory-produced goods are followed, in addition to careful delivery scheduling, following correct handling procedures, guaranteeing quality on-site, and government regulatory oversight of material standards. Compliance with regulations was rated second by the respondents with (MV=3.69). This is consistent with the findings of Dosumu and Aigbavboa (2022), who recommend that the government needs to establish favourable rules and regulations to foster the practice of sustainable construction. Esa *et al*. (2017) suggest that the environmental effects of improper waste management should be emphasised in regulations pertaining to the management of construction waste. Conducting regular inspections (MV=3.59) was ranked third. Udawatta *et al*. (2015) highlighted the necessity of conducting regular site inspections and reviewing waste management performance on a regular basis to identify additional waste reduction requirements.

The findings revealed that rigorous quality assurance to meet project specifications and reduce rework was the most important effective waste management practice on construction sites, with (MV=3.72). This is in line with the findings of Ajayi *et al*. (2016) who noted the common practice of starting construction with incomplete documents. Ajayi *et al*. (2016) highlighted that this tendency led to reworks, waste, cost overrun and even delays. Udawatta *et al*. (2015) assert that the main contractor is responsible for ensuring that subcontractor subcontractors comply with specifications, and construction workers are aware of the waste management practices. According to Table 4.21, collaboration with like-minded suppliers to encourage reusable and minimal packaging was rated first with (MV=3.70). This is supported by studies conducted by Jaillon *et al.* (2009), which demonstrate that such partnerships significantly lower the amount of waste produced on construction sites. Abarca-Guerrero *et al*. (2017) reveal that the construction industry can benefit from financial incentives linked to sustainable packaging and waste reduction initiatives. Inventory management to meet project specifications and reduce rework was also rated second with (MV=3.70). This result aligns with Liwan *et al*. (2013) who assert that inventory is crucial, particularly for construction projects, since having the right amount of inventory will guarantee that all work can be completed on time. Nanaware and Saharkar (2017) reveal that efforts made towards rationalising inventories can achieve a noticeable savings. Ranked third is local sourcing to minimise transport-related waste and emission with (MV=3.69). This finding is bolstered by Gálvez-Martos *et al*. (2018) who reveal that local sourcing practices could significantly minimise environmental impact by minimising the effects of transportation and lowering waste generation. Liu *et al*. (2020) suggest that construction waste can be significantly decreased by increasing project participants' understanding of waste management practices and safeguarding building supplies while they are being transported.

The findings in Table 4.22 revealed that training relating to safe material handling was rated first as the most significant effective waste management on construction site practice, with (MV=4.00). This result is consistent with the arguments made by Hasmori *et al*. (2020), who contend that to promote the reduction of construction waste on-site, it is necessary to use off-site products and components, provide waste skips for materials, standardise design and material, and handle construction materials properly. In addition, Jaillon *et al*. (2009) draw the conclusion that the selection of construction methods, the availability of on-site facilities for sorting and recycling construction waste, and the degree of worker education and training may all have a major impact on waste output on construction sites. Ensure materials meet quality standards (MV=4.00) were also rated first. This finding aligns with Mbote *et al.* (2016) who noted that government control over material standards, proper handling instructions during delivery, scheduled delivery, quality assurance at the site, and factory-produced goods meeting specified standards are all necessary for the manufacture and delivery of materials. Efficient storage and organisation of materials

(MV=3.85) was rated second. The findings were consistent with those of Nyika *et al*. (2019) and Liu *et al*. (2020), who identified project changes, material cutting for size, and storage issues as the primary causes of waste on construction sites. Reuse of materials whenever possible (MV=3.83) were rated third as most significant effective waste management in construction site practice. This finding is corroborated by Esa *et al*. (2017) who contend that, to optimise efficiency throughout the construction cycle, it is essential to implement the 3R principles of reduce, reuse, and recycle. Kabirifar *et al*. (2020) further suggest the implementation of a waste management hierarchy including the 3R principle to reduce waste on construction sites.

Among effective waste management in construction site practice, establishing clear communication channels among project operational team was rated first with (MV=3.96). Udawatta *et al*. (2015) corroborate this finding, arguing that transparent communication between subcontractors and the principal contractor can reduce construction waste. Gamil and Rahman (2021) add that the success of the construction sector is entirely dependent on efficient communication between individuals, teams, and organisations. Plan construction schedules with time buffers to avoid rushed work (MV=3.91) was ranked second. This finding is in line with Mbote *et al*. (2016) who found that setting aside enough time for each construction operation is essential to guaranteeing high-quality work and reducing the possibility of mistakes brought on by rushed work. Gamil and Rahman (2021) corroborate this finding by adding that regular and consistent communication is necessary to keep the project's operations flowing across the allotted timetable, which reduces delays and improves quality. Planning construction activities with weather forecasts in mind to minimise work stoppages during adverse conditions ranked third, with (MV=3.90). This conclusion is corroborated by Doloi *et al*. (2012), who contend that extreme weather conditions are typically disregarded during the design stage of construction.

As presented in Table 4.24 implement a policy that does not permit any unsafe practices was ranked first with (MV=4.03). This finding was content with Liu *et al*. (2020) who contend that construction waste management systems in many countries place insufficient emphasis on incentive policies or appropriate source plans for their reduction management initiatives. Liu *et al*. (2020) opine that the implementation of incentive policies and source plans constitute crucial strategies for addressing the issue of excessive construction waste generation. Enforcing a zero-tolerance policy for negligence (MV=4.00) was ranked second. This finding was in line with Darko *et al*. (2017), who contend that enforcing a stringent zero-tolerance policy lowers the frequency of accidents and injuries on construction sites by instilling in workers a sense of responsibility and communicating the significance of safety procedures. Additionally, Almahmoud and Doloi (2020) emphasise that implementing such a strategy not only shields employees from injury but also preserves the company's reputation and reduces legal liabilities related to carelessness. According to the findings to encourage open communication and value every team member's input (MV=3.94) was ranked third. This result was consistent with Dave and Koskela (2009), who argue that fostering an environment of open communication allows team members to exchange ideas, spot any problems early, and work together to solve them, all of which improve project outcomes.

4.9 Chapter summary

This chapter offers an analysis of the data, outlines the methods that were employed to gather the data, presents the results, and has a discussion of the outcomes. The Statistical Package for Social Sciences (SPSS) software, version 29, was used to analyse the data that were gathered. The survey's questions were created using a 5-point Likert scale, and mean score values were used to rank the analysis's findings. The number of respondents were 105 out of 201 questionnaires that were sent out to the respondents which was adequate to produce a significant result, as necessary for calculating statistical analysis, notwithstanding the low survey response. Additionally, the demographic data on the respondents including gender, education, and experience showed that they were informed enough about the subject and had enough expertise in the construction industry to merit further investigation.

The findings on contractors' perceptions of construction waste management indicate that, although good waste management strategies can result in large financial savings over the long run, there are still important concerns about the high costs of disposing of waste and the propensity to put short-term gains ahead of long-term gains as shown in Table 4.6. Table 4.7 highlights that resistance to using new waste reduction techniques, and uneven implementation of waste management policies all have an impact on management attitudes toward waste management. In addition, inadequate training is a significant problem since it results in workers' and site occupants' lack of understanding of safety concerns, waste management requirements, and the waste of recyclable or reuse items, which are the top-rated perceptions in Table 4.12. With respect to FA, the findings indicated the factors that influence management attitudes toward construction waste management variables the most: the variable addressed in component one “undermining compliance with waste management regulations”, component two was on “project requirements influence contractors’ perception regarding waste management approach”. These results highlight the need for more efficient training, more transparent policy enforcement, and constant communication to promote efficient and long-lasting waste management practices in the construction industry.

The analysis of key drivers influencing contractors' waste management practices reveals a complex interaction between environmental, economic, and social related factors, each ranked based on their Relative Importance Index (RII) as shown in Table 4.13 to Table 4.15. This table looks at the critical social, economic, and environmental factors affecting South African contractors' waste management practices. Emphasising the need for sustainable practices that reduce environmental effect and optimise resource usage, the results identify waste reduction and recycling, water conservation and management, and resource efficiency as significant environmental factors. Waste management practices are influenced by cost-effective and regulated elements, which is in line with the industry's emphasis on both. These factors include recycling opportunities, material costs, and regulatory compliance costs. Social aspects are also very important, highlighting the significance of community involvement, following best practices, and ongoing education in promoting sustainable waste management. These include public awareness, adherence to industry standards, and educational initiatives. The results indicate that to achieve complete and sustainable waste management solutions, a successful mechanism for reducing construction waste in South Africa must integrate these economic, social, and environmental issues.

The findings show that one of the challenges contractors have in reducing construction waste is the lack of waste reduction programmes. Waste reduction plans are vital guides that show how to reduce waste production, encourage recycling and reuse, and handle waste that is produced in an appropriate manner. The findings of the factor analysis (FA) revealed 7 essential elements that are causing difficulties in the reduction of construction waste. Component 1 emphasises "ineffective communication regarding waste reduction," highlighting problems with ambiguous objectives and tactics in attempts to minimise waste. The second component highlights "limited access to recycling facilities," which denotes obstacles to the availability of recycling infrastructure on construction sites. Component 3 refers to the "improper reuse of materials on-site," highlighting inefficiencies or overlooked chances in the process of reusing construction materials. Component 4, which denotes "lack of a zero-waste culture in the construction worksite," highlights the need for cultural changes aimed at implementing waste reduction techniques. The 5th component, "identification of nearby recycling facilities," highlights the difficulties in finding and making use of recycling services. Component 6 refers to "the use of inadequate equipment," implying that some equipment is not suitable for duties involving efficient waste management”. The final component, Component 7, denotes "difficulties in tracking waste on-site," which refers to difficulties in keeping an effective eye on and managing waste streams during construction projects.

The findings on construction waste management practices in South Africa reveal that construction waste may be significantly reduced on sites by using techniques like materials selection, procurement, handling, operation, and culture as presented in Table 4.20 to Table 4.24. Construction companies can enhance resource utilisation and reduce their environmental impact by prioritising sustainable material choices, implementing efficient procurement procedures, ensuring safe and effective handling practices, optimising operational efficiencies, and fostering a waste-conscious organisational culture.

The findings on effective waste management practices in South Africa highlight the importance of materials selection, procurement, handling, operation, and organisational culture. Materials selection was identified as the most significant method, emphasising compliance with regulations, conducting inspections, and adhering to standards to reduce waste. Efficient procurement practices, such as quality assurance, collaboration with suppliers for sustainable packaging, and inventory management, were also crucial. Proper handling of materials, including training, ensuring quality standards, and implementing the 3R principles (reduce, reuse, recycle), further minimised waste. Operational efficiencies, like clear communication among teams, scheduling with time buffers, and planning for weather conditions, were deemed essential. Lastly, fostering a waste-conscious culture through policies against unsafe practices, zero-tolerance for negligence, and encouraging open communication were found to significantly enhance waste management on construction sites.

CHAPTER FIVE

CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS FOR FURTHER RESEARCH

5.1 Introduction

This chapter presents the research findings, the project's limitations, recommendations, and potential directions for future study in relation to effective framework to reduce construction waste in South Africa. The aim and objectives of the study were expounded upon in greater detail in the previous chapters. The aim of this study is to develop a waste management framework to aid the reduction of construction waste in the SACI. The following objectives were established to fulfil the aim of this research study:

i. To investigate the perceptions of contractors regarding construction waste management in construction sites.
ii. To determine key drivers for contractor's waste management practices in construction sites.
iii. To determine the challenges experienced by contractors regarding the reduction of construction waste.
iv. To determine the various construction practices adopted by contractors to reduce construction waste.
v. To propose an effective framework for contractors to reduce construction waste in South Africa.

5.2 Conclusions

The study's conclusion has been reached based on empirical findings for each of the specified objectives; each conclusion has been thoroughly discussed to demonstrate that the objective was met.

5.2.1 Perceptions of contractors regarding construction waste management in construction sites

Several significant insights are revealed by the findings of the study on contractors' perspectives of construction waste management. Although most contractors are aware of the long-term financial benefits that efficient waste management may provide, the upfront expenses connected with putting such procedures into place as well as the immediate financial strains continue to be major obstacles. To recruit contractors, it is suggested that greater focus be put on demonstrating the long-term financial advantages of waste reduction techniques. As a reflection of the financial consequences of poor waste management, waste disposal costs are also frequently mentioned as a significant concern. To reduce these costs and promote better waste management practices, specific policies like recycling subsidies or waste management infrastructure subsidies may be helpful. The inclination of contractors to put immediate cost savings ahead of long-term sustainability is another important finding. This demonstrates the difficulty in resolving the short-term financial strains that contractors experience and points to the necessity of short-term measures such as financial incentives or regulatory frameworks that increase the attraction of sustainable waste management. It is further suggested that waste management issues are systemic and independent of contractor size and expertise by the consistency in cost-related perceptions among contractors of different cidb grades. This necessitates industry-wide solutions that can tackle the shared financial obstacles that all contractors' encounters. The necessity of systemic initiatives to assist contractors in overcoming the financial obstacles to waste management is generally highlighted by these findings. Encouraging broader adoption of sustainable practices may require providing grants, tax rebates, or financial incentives. More instruction that emphasizes the immediate as well as long-term advantages of waste reduction may also assist contractors in making better waste management choices, which would ultimately promote a more environmentally friendly construction industry.

5.2.2 Key drivers for contractor's waste management practices in construction sites

The study highlights the key drivers shaping contractors' waste management practices, which are primarily influenced by environmental, economic, and social factors. Environmentally, recycling and waste reduction, water conservation, and resource management emerged as the most critical drivers, underscoring the need for sustainable construction practices to reduce environmental impacts and promote resource efficiency. Economically, recycling opportunities, material costs, and regulatory compliance costs were identified as major motivators, with contractors recognizing the cost-saving potential of recycling and efficient material management. Socially, public awareness, adherence to industry standards, and educational initiatives were seen as essential for encouraging more sustainable practices, with a particular focus on increasing community involvement and providing ongoing training for contractors.

5.2.3 Challenges experienced by contractors related to reduction of construction waste

The construction industry needs a broader solution to a well-known problem, contractors have been struggling to reduce construction waste for decades. The findings highlight systemic deficiencies, for example lack of integrated systems, lack of robust solid waste management plans as major barriers to effective waste reduction. These are made worse by operational deficiencies like deficient on-site recycling facilities, waste separation, poor communications, and insufficient training. Other cultural factors involved are a stress on output vs sustainability, and the absence of a zero-waste mindset.

According to the factor analysis, poor communication is a major obstacle to construction waste management, and it is linked to operational and systemic issues such poor waste segregation, insufficient training, a lack of integrated waste management systems, and inadequate planning. Cost-related obstacles, a lack of on-site space, and contractors' emphasis on output over sustainability exacerbate these problems. In addition to stressing the significance of developing a zero-waste culture and putting sustainable procurement and lean construction techniques into practice to improve waste reduction efforts, the findings underscore the urgent need for clear communication, stakeholder collaboration, and focused training to address these deficiencies.

Critical obstacles to efficient construction waste management are highlighted by the findings, such as the lack of a zero-waste culture, insufficient equipment, ambiguous roles, and challenges with on-site waste tracking. These problems are made worse by a lack of sustainable procurement practices, limited access to recycling facilities, and inadequate worker and contractor training. To increase the effectiveness of waste treatment, the study highlights the necessity of making investments in cutting-edge technology, giving sustainable material selection priority, and putting in place extensive waste management systems. Addressing these issues and promoting sustainable practices in the construction sector also depend on developing a zero-waste culture via instruction, training, and clearly defined accountability.

5.2.4 Construction practices adopted by contractors to reduce construction waste

The findings highlight key practices for effective construction waste management, with material selection being the most significant, emphasizing compliance with standards and proper handling. Rigorous procurement processes, such as quality assurance and supplier collaboration, play a crucial role in reducing waste. Training in material handling, ensuring quality, and efficient storage emerged as critical factors, alongside operational measures like clear communication and scheduling to avoid rushed work. A strong safety culture, including zero-tolerance policies for unsafe practices and negligence, further supports waste reduction efforts. These strategies collectively enhance efficiency, sustainability, and environmental stewardship in construction projects.

5.2.5 Effective framework for construction waste reduction in South Africa

An effective framework for contractors to reduce construction waste in South Africa is illustrated in figure 5.1. This framework is intended to address the urgent problem of construction waste reduction in South Africa. The figure illustrates the interdependencies between different elements that impact the creation of a framework that helps contractors cut down on waste during construction. To effectively reduce construction waste in South Africa, a multifaceted framework must address the perceptions of contractors, key drivers for waste management, prevailing challenges, and current practices. Firstly, addressing contractors' perceptions involves introducing financial incentives such as subsidies for waste management infrastructure, tax rebates, and grants to offset the high upfront costs associated with sustainable practices. Educational programmes highlighting the long-term financial benefits of waste reduction can help shift contractor priorities from short-term cost savings to sustainable approaches. Regulatory and policy frameworks should enforce mandatory practices like waste segregation and on-site recycling while providing short-term incentives to enhance compliance. Industry-wide initiatives that standardize waste management practices and provide shared access to recycling facilities can address systemic challenges faced by contractors across all cidb grades.

Key drivers for waste management practices environmental, economic, and social must also be leveraged. Environmental initiatives should focus on promoting sustainable construction techniques, resource efficiency, and water conservation. Economic drivers, such as expanding recycling opportunities, encouraging the use of prefabricated and recycled materials, and reducing material costs, are essential. Socially, public awareness campaigns, community collaborations, and continuous training programmes for contractors can foster a culture of sustainability. Enhancing stakeholder involvement and emphasizing the societal benefits of responsible waste management are equally critical.

To overcome challenges, integrated waste management systems are necessary to streamline waste tracking, segregation, and disposal. Investments in smart technologies can further optimize waste monitoring and improve efficiency. Training programmes should target contractors and workers, focusing on waste segregation, recycling techniques, and sustainable procurement. Improved communication among stakeholders is vital for clear role definition and responsibility allocation in waste management efforts. Infrastructure improvements, including on-site recycling and waste segregation facilities, should address logistical barriers, while promoting a zero-waste culture through campaigns and leadership commitment is essential for long-term change.

Lastly, construction waste management practices in South Africa Material selection are critical, ensuring compliance with standards, proper handling, and adopting environmentally sustainable options. Rigorous procurement processes, including quality assurance, supplier collaboration, and inventory management, are essential to minimise rework and reduce waste. Training in material handling, efficient storage, and adherence to the 3R principles (reduce, reuse, recycle) must be prioritised. Operationally, clear communication, well-planned schedules, and adaptability to environmental conditions can mitigate delays and prevent waste. Fostering a strong safety and accountability culture, including implementing zero-tolerance policies and encouraging collaboration, will enhance sustainability. This comprehensive approach ensures waste reduction while promoting efficiency, compliance, and environmental responsibility.

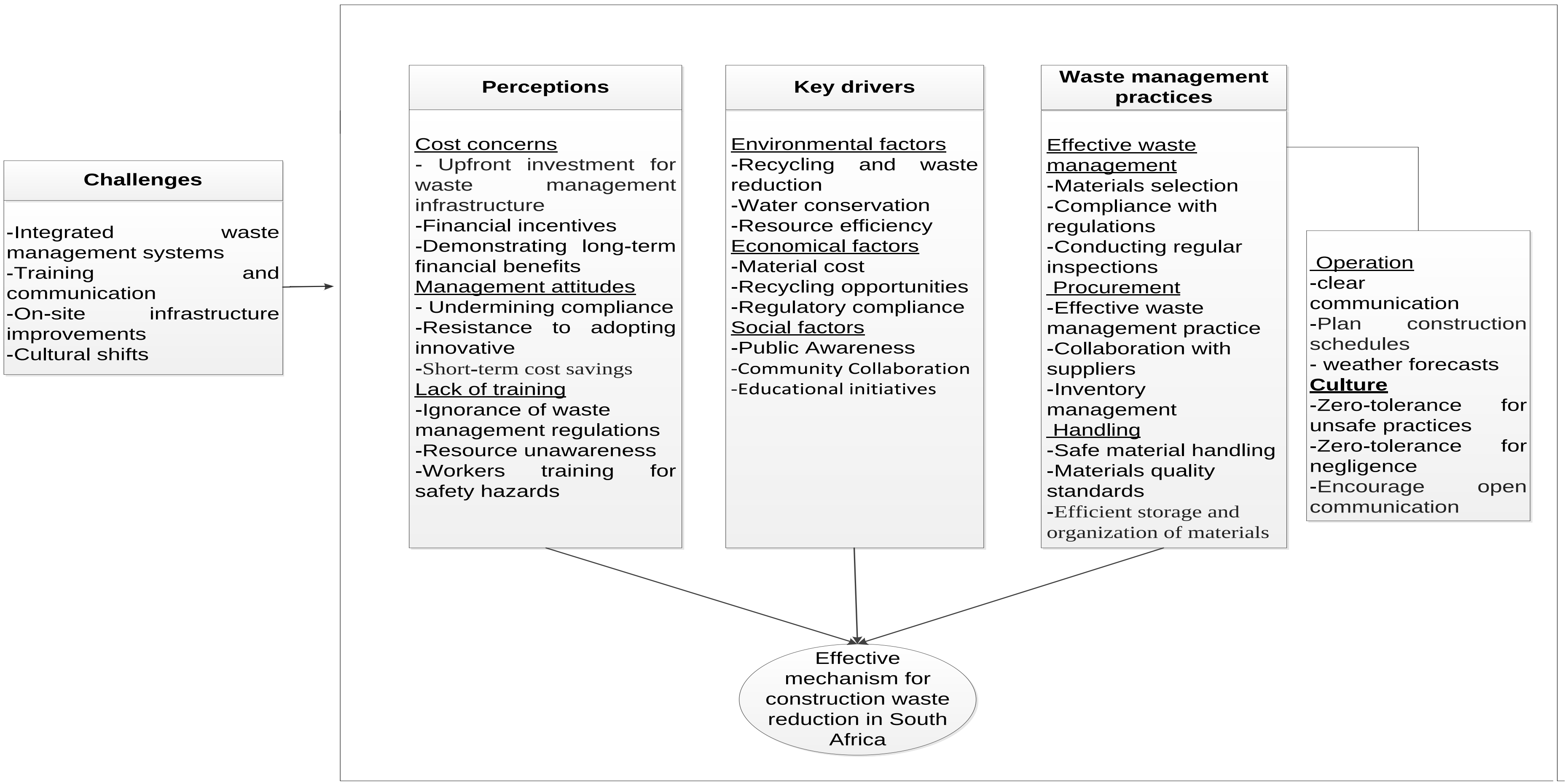

Figure 5.1 Effective framework for contractors to reduce construction waste in South Africa (Researcher's own source).

5.3 Limitations

This study was carried out in South Africa in the Eastern Cape province. The Eastern Cape province-registered contractors with cidb Grades 5–9 of General Building (GB) is the subject of this study. Data collection from workers in the construction industry was challenging for several reasons. The chosen respondents' busy schedules constituted a significant barrier. Many of them mentioned that they struggled to find time to take part because of their time-consuming duties on building sites, contractual obligations to attend meetings, and general pressure to finish projects on schedule. As such, many respondents were unable to keep their promise to finish and submit the surveys within the specified timeframe. In addition, a few professionals chose not to participate in the survey due to the priority of completing their pending tasks over taking the survey. Together, these variables resulted in a considerable percentage of the disseminated questionnaires being returned incomplete, rendering them unusable for the study's objectives and necessitating their exclusion from the study.

5.4 Recommendations

This study focused on investigating contractor perceptions, identifying key drivers and challenges faced by contractors and analysing current waste management practices to develop a waste management framework that would help reduce construction waste in the SACI. While the government and stakeholders in the SACI are making every effort to reduce the amount of waste produced on construction sites, it is crucial to identify a sustainable system's path so that waste can be managed without negatively impacting the environment. The following recommendations are based on the survey's results and conclusions:

- Similar research with a larger sample size should be carried out, with a specific focus on building construction companies outside of the Eastern Cape, and the results should be compared with the findings of this study.
- The findings confirm that there is a need to raise the knowledge of contractors regarding the significance of waste management on construction sites; this should be done by holding workshops, seminars, and training sessions.
- Contractors should ensure that they have enough resources, like disposal sites, waste sorting equipment, and recycling centres, to enable effective waste management.
- Government should create an enforceable policy that supports the implementation of sustainable waste management plans by all construction companies to facilitate the management of waste on construction sites.

- Government should provide programmes for accreditation that honour and incentivise contractors who show a dedication to environmentally responsible waste management.
- Encourage cooperation between waste management companies, suppliers, developers, and contractors to exchange ideas, innovations, and best practices.

5.5 Recommendation for further studies

The following recommendations are made for further research:

- Examine methods for encouraging cooperation and participation from all parties engaged in managing construction waste, such as local communities, government organisations, contractors, and environmental groups.
- More research on waste estimate can be conducted using a more precise and accurate model that will quantify waste at each stage of the construction life cycle on carefully selected construction sites.
- Further studies on the influence of industry standards, institutional frameworks, and governmental legislation on building waste management practices.

References

Abarca-Guerrero, L., Maas, G. & Van Twillert, H. 2017. Barriers and motivations for construction waste reduction practices in Costa Rica. *Resources*, *6*(4), 1-14.

Abd Elkodous, M., Hamad, H.A., Abdel Maksoud, M.I., Ali, G.A., El Abboubi, M., Bedir, A.G., Eldeeb, A.A., Ayed, A.A., Gargar, Z., Zaki, F.S. & Farage, D.A. 2022. Cutting-edge development in waste-recycled nanomaterials for energy storage and conversion applications. *Nanotechnology Reviews*, *11*(1), 2215-2294.

Abdel-Shafy, H.I. & Mansour, M.S.M. 2018. Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, 27(1), 1275–1290.

Abidin, N.Z. & Yusof, N-A. 2013. Enablers and challenges of a sustainable housing industry in Malaysia. *Construction Innovation*, 13(1), 10-25.

Aboginije, A., Aigbavboa, C. & Thwala, W. 2020. Determining the impact of construction and demolition waste reduction practices on green building projects in Gauteng province, South Africa. Proceedings of the International Conference on Industrial Engineering and Operations Management Dubai, UAE,10-12 March.

Abubakar, I.R., Maniruzzaman, K.M., Dano, U.L., AlShihri, F.S., AlShammari, M.S., Ahmed, S.M.S., Al-Gehlani, W.A.G. & Alrawaf, T.I. 2022. Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South. *International Journal Environmental Research and Public Health*, 19(1), 1-26.

Aigbavboa, C., Ohiomah, I. & Zwane, T. 2017. Sustainable construction practices: “a lazy view” of construction professionals in the South Africa construction industry. *Energy Procedia*, 105(1), 3003-3010.

Ajayi, V.O. 2017. Primary sources of data and secondary sources of data. *Benue State University*, *1*(1), 1-6.

Ajayi, S. O. & Oyedele, L. O. 2018. Critical design factors for minimising waste in construction projects: A structural equation modelling approach. *Resources, Conservation & Recycling*, 137(1), 302-313.

Ajayi, S. O., Oyedele, L. O., Bilal, M., Akinade, O. O., Alaka, H. A., Owolabi, H. A. & Kadiri, K. O. 2015. Waste effectiveness of the construction industry: Understanding the impediments and requisites for improvements. *Resources, Conservation and Recycling*, 102(1), 101–112.

Ajayi, S. O., Oyedele, L. O., Akinade, O. O., Bilal, M., Owolabi, H. A., Alaka, H. A. & Kadiri, K. O. 2016. Reducing waste to landfill: A need for cultural change in the UK construction industry. *Journal of Building Engineering,* 5(1), 185-193.

Ajayi, S.O., Oyedele, L.O., Akinade, O.O., Bilal, M., Alaka, H.A. & Owolabi, H.A. 2017. Optimising material procurement for construction waste minimization: An exploration of success factors. *Sustainable materials and technologies*, *11*, 38-46.

Akadiri, P.O., Chinyio, E.A. & Olomolaiye, P.O. 2012. Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector. *Buildings*, 2(2), 126-152.

Akhtar, A. & Sarmah, A.K. 2018. Construction and demolition waste generation and properties of recycled aggregate concrete: A global perspective. *Journal of Cleaner Production*, *186*, 262-281.

Aksel, H. & Cetıner, İ. 2020. Construction waste management practices on-sites: A case study of Istanbul city. *Environmental Research and Technology*, 3(2), 50-63.

Alaloul, W. S., Musarat, M. A., Rabbani, M. B. A., Iqbal, Q., Maqsoom, A. & Farooq, W. 2022. Construction Sector Contribution to Economic Stability: Malaysian GDP Distribution. *Sustainability*, 13(1), 1-26.

Ali, A.S., Kamaruzzaman, S.N. & Sing, G.C. 2010. A Study on causes of accident and prevention in Malaysian construction industry. *Journal of Design Built*, *3*(1), 95-104.

Ali, T. H., Akhund, M. A., Imad, H. U., Memon, A. H. & Khahro, S. H. 2019. Application of Artifical Intelligence in Construction Waste Management. International Conference on Industrial Technology and Management, 50-55.

Alharahsheh, H.H. & Pius, A. 2020. A review of key paradigms: Positivism VS interpretivism. *Global Academic Journal of Humanities and Social Sciences*, *2*(3), 39-43.

Allen, L., Feng, M.D., Nicholas, C., Wesely, B.S., Lloyd, P., Hoehle, B.S., Katie, M., Phillips M.D, Alisa, M.D, Adam, P. Campbell, M.D, Luciano, L., Gregorio, M.D., Thomas, E., Killeen, M.D., David, S., Caradonna, M.D., Josh, C., Meier, M.D., Stacey, T., Gray, M.D., Ahmad, R. & Sedaghat, M.D. 2017. A validated model for the 22-item Sino-Nasal Outcome Test subdomain structure in chronic rhinosinusitis. *International Forum of Allergy & Rhinology*, 7(12),1140-1148.

Almahmoud, E & Doloi, H.A. 2020. Identifying the key factors in construction projects that affect neighbourhood social sustainability. *Facilities*, 38(11), 765-782.

Alordiah, C.O. & Chenube, O. 2023. Item Rotation in Scale Development. *Nigerian Journal of Social Psychology*, *6*(2).

Alwan, Z., Jones, P. & Holgate, P. 2017. Strategic sustainable development in the UK construction industry, through the framework for strategic sustainable development, using Building Information Modelling. *Journal of cleaner production*, 1(140), 349-358.

Andrew, S., Salamonson, Y., Everett, B., Halcomb, E. & Davidson, P.M. 2010. Beyond the ceiling effect: Using a mixed methods approach to measure patient satisfaction. *International Journal of Multiple Research Approaches*, 5(1), 52-63.

Asdrubali, F., Ferracuti, B., Lombardi, L., Guattari, C., Evangelisti, L. & Grazieschi, G. 2017. A review of structural, thermo-physical, acoustical, and environmental properties of wooden materials for building applications. *Building and Environment*, 114(1), 307-332.

Asimakopoulos, G., Christodoulou, S., Gizas, A., Triantafillou, V., Tzimas, G., Viennas, E., Gialelis, J., Karadimas, D. & Papalambrou, A. 2015. Towards a dynamic waste collection management system using real-time and forecasted data. In *Proceedings of the 16th international conference on engineering applications of neural networks (INNS)*,1-9, September.

Azungah, T. 2018. Qualitative research: deductive and inductive approaches to data analysis. *Qualitative research journal*, *18*(4), 383-400.

Azzi, E. 2017. Waste Management Systems in Lebanon: The benefits of a waste crisis for improvement of practices.

Babatunde, S.O., Perera, S., Ekundayo, D. & Adeleye, T.E. 2019. An investigation into BIM-based detailed cost estimating and drivers to the adoption of BIM in quantity surveying practices. *Journal of Financial Management of Property and Construction*, 25(1), 61-81.

Bajjou, M. S., Chafi, A. & En-Nadi, A. 2017. A comparative study between lean construction and the traditional production system. *International Journal of Engineering Research in Africa*, 29(1), 118-132.

Bakchan, A. & Faust, K. M. 2019. Construction waste generation estimates of institutional building projects: Leveraging waste hauling tickets. *Waste Management*, 87(1), 301-312.

Balaram, V. 2019. Rare earth elements: A review of applications, occurrence, exploration, analysis, recycling, and environmental impact. *Geoscience Frontiers*, *10*(4), 1285-1303.

Bandalos, D.L. & Finney, S.J. 2018. Factor analysis: Exploratory and confirmatory. In *The reviewer's guide to quantitative methods in the social sciences*. Routledge, 98-122.
Bansal, A., Mishral, G. & Bishnoi, L. 2016. Recycling and re-use of construction and demolition waste. DOI: https://www.researchgate.net/publication/314065807.

Bao, Z. & Lu, W. 2021. A decision-support framework for planning construction waste recycling: A case study of Shenzhen, China. *Journal of Cleaner Production,* 309(1), 1-12.

Bao, Z., Lee, W.M. & Lu, W. 2020. Implementing on-site construction waste recycling in Hong Kong: Barriers and facilitators. *Science of the Total Environment*, *747*, 141091.

Bates, A.J., Sadler, J.P., Greswell, R.B. & Mackay, R. 2015. Effects of varying organic matter content on the development of green roof vegetation: A six-year experiment. *Ecological Engineering,* 82(1), 301–310.

Bertino, G., Kisser, J., Zeilinger, J., Langergraber, G., Fischer, T. & Österreicher, D. Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials. *Applied Sciences*, 11(3), 1-30.

Bhattacherjee, A. 2012. *Social Science Research: Principles, Methods and Practices*. 2nd ed. Florida: The Global Text Project.

Biggam, J. 2011. Succeeding With Your Masters Dissertation: A Step-By-Step Handbook. *McGraw-Hill International, 14*(3), 1360-1431.

Bilal, M., Oyedele, L. O., Akinade, O. O., Ajayi, S. O., Alaka, H. A., Owolabi, H. A., Qadir, J., Pasha, M. & Bello, S. 2016. Big data architecture for construction waste analytics (CWA): A conceptual framework. *Journal of Building Engineering*, 6(1), 144-156.

Blair, J. & Mataraarachchi, S. 2021. A review of landfills, waste and the nearly forgotten nexus with climate change. *Environments*, *8*(8), 73.

Blismas, N. & Wakefield, R. 2008. Drivers, constraints and the future of offsite manufacture in Australia. *Construction Innovation,* 9(1), 72-83.

Bryson, J.M., Crosby, B.C. & Stone, M.M. 2015. Designing and implementing cross-sector collaborations: Needed and challenging. *Public administration review*, *75*(5), 647-663.

Burger, J. & Gochfeld, M. 2016. Initiating events, functional remediation, and assessment of risk to ecological resources. *Ecological indicators*, *71*, 32-40.

Chand, S., Shastry, C.S., Hiremath, S., Joel, J.J., Bhat, C.K. & Mateti, U.V. 2020. Water, sanitation, hygiene and biomedical waste disposal in the healthcare system: A review. *Biomedicine*, *40*(1), 14-19.

Chen, J., Hua, C. & Liu, C. 2019. Considerations for better construction and demolition waste management: Identifying the decision behaviours of contractors and government departments through a game theory decision-making model. *Journal of Cleaner Production*, *212*(1), 190-199.

Chen, Q., Adey, B.T., Haas, C. & Hall, D.M. 2020. Using look-ahead plans to improve material flow processes on construction projects when using BIM and RFID technologies. *Construction innovation*, *20*(3), 471-508.

Cheng, B., Huang, J., Guo, Z., Li, J. & Chen, H. 2022. Towards sustainable construction through better construction and demolition waste management practices: A SWOT analysis of Suzhou, China. *International Journal of Construction Management, 9*(1), 163–185.

Chidiobi, C. 2022. *Development of Frameworks for the Management of Materials Procurement and Construction Waste for Nigerian Contractors.* (Doctoral dissertation, University of the West of England).

Choudhry, R.M. 2014. Behavior-based safety on construction sites: A case study. *Accident analysis & prevention*, *70*, 14-23.

Coghlan, D. 2019. Doing action research in your own organization, 1-240.

Cooksey, R.W. & Cooksey, R.W. 2020. Descriptive statistics for summarising data. *Illustrating statistical procedures: Finding meaning in quantitative data*, 61-139.

Coskun, S. 2022. Zero waste management behavior: Conceptualization, scale development and validation - A case study in Turkey. *Sustainability*, *14*(19), 12654.

Crawford, R. H., Mathur, D. M. & Gerritsen, R. 2017. Barriers to improving the environmental performance of construction waste management in remote communities. *Procedia Engineering*, *196*(1), 830-837.

Creswell, J.W. 2007. *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage Publications.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed). Thousand Oaks, CA: Sage.

Creswell, J.W. & Garrett, A.L. 2008. The “movement” of mixed methods research and the role of educators. *South African journal of education*, *28*(3), 321-333.

Creswell, J.W., Klassen, A.C., Clark, P.V.L. & Smith, K.C. 2011. *Best practices for mixed methods research in the health sciences*. Bethesda (Maryland): National Institutes of Health, 541-545.

Dada, M.A., Obaigbena, A., Majemite, M.T., Oliha, J.S. & Biu, P.W. 2024. Innovative approaches to waste resource management: implications for environmental sustainability and policy. *Engineering Science & Technology Journal*, *5*(1), 115-127.

Daian, G. & Ozarska, B. 2009. Wood waste management practices and strategies to increase sustainability standards in the Australian wooden furniture manufacturing sector. *Journal of Cleaner Production*, 17(1), 1594–1602.

Darko, A., Chan, A. P. C., Ameyaw, E. E., Bao-Jie, H. & Olanipekun, A. O. 2017. Examining issues influencing green building technologies adoption: The United States green building experts’ perspectives. *Energy and Buildings, 144*, 320-332.

Das, S., Lee, S.H., Kumar, P., Kim, K-H., Lee, S.S. & Bhattacharya, S.S. 2019. Solid waste management: Scope and the challenge of sustainability. *Journal of Cleaner Production, 228*(1), 658-678.

Dave, B. & Koskela, L. 2009. Collaborative knowledge management—A construction case study. *Automation in construction*, *18*(7), 894-902.

Denscombe, M. 2008. Communities of practice: A research paradigm for the mixed methods approach. *Journal of mixed methods research*, *2*(3), 270-283.

de Valence, G. 2019. Reframing construction within the built environment sector. *Engineering, Construction and Architectural Management*, *26*(5), 740-745.

Delaware, K. 2003. Construction and demolition waste: Assessment of demand and supply of recycling materials in the Western Cape. University of Cape Town, 1-119.

Department of Environmental Affairs (DEA). 2018. South Africa state of waste. A report on the state of the environment. First draft report. Pretoria: RSA.

Doloi, H., Sawhney, A., Iyer, K.C.& Rentala, S. 2012. Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management*, *30*(1), 479–489.

Dong, Y.H. & Ng, S.T. 2015. A life cycle assessment model for evaluating the environmental impacts of building construction in Hong Kong. *Building and Environment,* 89(1), 183-191.

Dosumu, O. & Aigbavboa, C. 2019. Drivers and effects of sustainable construction in the South African construction industry. *Acta Structilia*, *28*(2), 78-107.

Durdyev, S., Ismail, S., Ihtiyar, A., Bakar, N. F. S. A. & Darko, A. 2018. A partial least squares structural equation modeling (PLS-SEM) of barriers to sustainable construction in Malaysia. *Journal of Cleaner Production, 204*(1), 564-572.

Edwards, P., Roberts, I., Clarke, M., DiGuiseppi, C., Pratap, S., Wentz, R. & Kwan, I. 2002. Increasing response rates to postal questionnaires: systematic review. *Bmj*, *324*(7347), 1183.

Emina, K. A. 2021. Sustainable development and the future generations. *Social Sciences, Humanities and Education Journal, 2*(1), 57-71.

Esa, M. R., Haloga, A. & Rigamonti, L. 2017. Strategies for minimizing construction and demolition wastes in Malaysia. *Resources, Conservation and Recycling*, *120*(1), 219-229.

Ezeah, C., Fazakerley, J.A. & Roberts, C.L. 2013. Emerging trends in informal sector recycling in developing and transition countries. *Waste Management*, *33*(1), 2509–2519.

Fapohunda, J. A. 2014. Evaluation of site managers' hindrances towards optimal utilisation of construction resources. *Journal of Engineering, Design and Technology*, *12*(3), 348-363.

Fei, W., Opoku, A., Agyekum, K., Oppon, J. A., Ahmed, V., Chen, C. & Lok, K. L. 2021. The Critical Role of the Construction Industry in Achieving the Sustainable Development Goals (SDGs): Delivering Projects for the Common Good. *Sustainability*, *13*(1), 1-20.

Fellows, R. & Liu, A. 2008. *Research Methods for Construction*. Oxford: Wiley-Blackwell.

Ferrara, M., Fabrizio, E., Virgone, J. & Filippi, M. 2016. Energy systems in cost-optimized design of nearly zero-energy buildings. *Automation in Construction*, *70*, 109-127.

Ferronato, N. & Torretta, V. 2019. Waste Mismanagement in Developing Countries: A Review of Global Issues. *International Journal of Environmental Research and Public Health*, *16*(6), 1-28.

Fife-Schaw, C. 2020. Questionnaire design. *Research methods in psychology*, 343-374.

Galvez-Martos, J-L., Styles, D., Schoenberger, H., & Zeschmar-Lahl, B. 2018. Construction and demolition waste best management practice in Europe. *Resources, Conservation & Recycling*, *136*(1), 166-178.

Gamil, Y. & Rahman, I.A. 2021. Studying the relationship between causes and effects of poor communication in construction projects using PLS-SEM approach. *Journal of Facilities Management*, *21*(1), 102-148.

Gangolells, M., Casals, M., Forcada, N. Macarulla, M. 2014. Analysis of the implementation of effective waste management practices in construction projects and sites. *Resources, conservation and recycling*, *93*, 99-111.

Gencel, O., Bayraktar, O.Y., Kaplan, G., Arslan, O., Nodehi, M., Benli, A., Gholampour, A. & Ozbakkaloglu, T. 2022. Lightweight foam concrete containing expanded perlite and glass sand: Physico-mechanical, durability, and insulation properties. *Construction and Building Materials*, *320*, 126187.

George, D. & Mallery, P. 2018. Descriptive statistics. In *IBM SPSS Statistics 25 Step by Step*. Routledge. 126-134.

Ghaffar, S.H., Burman, M. & Braimah, N. 2020. Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery. *Journal of cleaner production*, *244*, 118710.

Gharfalkar, M., Court, R., Campbell, C., Ali, Z. & Hillier, G. 2015. Analysis of waste hierarchy in the European waste directive 2008/98/EC. *Waste Management*, *39*(1), 305-313.

Ghisellini, P., Ji, X., Liu, G. & Ulgiati, S. 2018. Evaluating the transition towards cleaner production in the construction and demolition sector of China: A review. *Journal of Cleaner Production*, *195*(1), 418-434.

Godfrey, L. & Oelofse, S. 2017. Historical Review of Waste Management and Recycling in South Africa. *Resources*, *6*(57), 1-24.

Greenhalgh, B. & Squires, G. 2011. *Introduction to Building Procurement*, 1st Edition. London, 1- 4.

Gumbi, S.E. 2015. Current waste management and minimisation patterns and practices: An exploratory study on the Ekurhuleni Metropolitan Municipality in South Africa. PhD diss., University of South Africa.

Gunningham, N. & Sinclair, D. 2019. Regulatory pluralism: Designing policy mixes for environmental protection. In *Environmental Law*. Routledge. 463-490.

Gupta, M. C., Prasad, M. S., Murali, I. A. S. & Beush, A. 2015. *Construction technology and building materials*, 1-117.

Gursel, A.P., Shehabi, A. & Horvath, A. 2023. Embodied energy and greenhouse gas emission trends from major construction materials of US office buildings constructed after the mid-1940s. *Building and Environment*, *234*, 110196.

Hakanen, E. & Rajala, R. 2018. Material intelligence as a driver for value creation in IoT-enabled business ecosystems. *Journal of Business & Industrial Marketing*, *33*(6), 1-12.

Hasmori, M. F., Zin, A. F. M., Nagapan, S., Deraman, R., Abas, N., Yunus, R. & Klufallah, M. 2020. The on-site waste minimization practices for construction waste. *IOP Conf. Series: Materials Science and Engineering*, *713*(1), 1-12.

Holcomb, Z. 2016. *Fundamentals of descriptive statistics*. Routledge.

Howell, G. & Koskela, L. 2000. Reforming project management: The role of lean construction. *In: Proceedings 8th Annual Conference of the International Group for Lean Construction*, Brighton,17–19 July.

Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R. & Ren, J. 2018. Construction and demolition waste management in China through the 3R principle. *Resources, Conservation and Recycling*, *129*, 36-44.

Hung, F. C. & Kamaludin, N. S. 2017. Professionals' views on material waste level and causes of construction waste generation in Malaysia. *Malaysian Construction Research Journal*, *21*(1), 33-53.

Ikau, R., Joseph, C. & Tawie, R. 2016. Factors Influencing Waste Generation in the Construction Industry in Malaysia. *Procedia - Social and Behavioral Sciences, 234*(1), 11-18.

Islam, R., Nazifa, T. H., Yuniarto, A., Uddin, A. S. M. S., Salmiati, S. & Shahid, S. 2019. An empirical study of construction and demolition waste generation and implication of recycling. *International Journal of Waste Management, 95*(1), 10-21.

Ismaeel, W. S. E. & Kassim, N. 2023. An environmental management plan for construction waste management. *Ain Shams Engineering Journal*, *13*(4), 1-13.

Jaillon, L., Poon, C.S. & Chiang, Y.H. 2008. Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong. *Waste Management*, *29*(1), 309–320.

Jamil, A.H.A. & Fathi, M.S. 2018. Contractual challenges for BIM-based construction projects: A systematic review. *Built Environment Project and Asset Management*, *8*(4), 372-385.

Janakova, I., Cech, M., Grabovska, S., Sigut, O., Sala, P. & Kijo-Kleczkowska, A. 2024. Pyrolysis of Specific Non-Recyclable Waste Materials: Energy Recovery and Detailed Product Characteristics. *Materials*, *17*(8), 1752.

Janse van Rensburg, R. 2022. *Waste prevention in South Africa: An evaluation of waste management regulations, policies and plans* (Doctoral dissertation, North-West University (South Africa)).

Jethy, B., Paul, S., Das, S.K., Adesina, A. & Mustakim, S.M. 2022. Critical review on the evolution, properties, and utilization of plastic wastes for construction applications. *Journal of Material Cycles and Waste Management*, *24*(2), 435-451.

Jikeka, S., Smallwood, J., Emuze, F. & Simpeh, E. 2020. Waste management: The case of construction and demolition waste in Port Elizabeth. *Sustainable Ecological Engineering Design*, 451-462.

Jones, M., Mautner, A., Luenco, S., Bismarck, A. & John, S. 2020. Engineered mycelium composite construction materials from fungal biorefineries: A critical review. *Materials & Design*, *187*, 108397.

Kabirifar, K., Mojtahedi, M., Wang, C. & Tam, V.W. Y. 2020. Construction and demolition waste management contributing factors coupled with reduce, reuse, and recycle strategies for effective waste management: A review. *Journal of Cleaner Production*, *263*(1), 1-16.

Kalkanis, K., Alexakis, D.E., Kyriakis, E., Kiskira, K., Lorenzo-Llanes, J., Themelis, N.J. & Psomopoulos, C.S. 2022. Transforming waste to wealth, achieving circular economy. *Circular Economy and Sustainability*, *2*(4), 1541-1559.

Kang, K., Besklubova, S., Dai, Y. & Zhong, R.Y. 2022. Building demolition waste management through smart BIM: A case study in Hong Kong. *Waste Management*, *143*, 69-83.

Kaur, P., Stoltzfus, J. & Yellapu, V. 2018. Descriptive statistics. *International Journal of Academic Medicine*, *4*(1), 60-63.

Kazakis, N., Kougias, I. & Patsialis, T. 2015. Assessment of flood hazard areas at a regional scale using an index-based approach and Analytical Hierarchy Process: Application in Rhodope–Evros region, Greece. *Science of the Total Environment*, *538*, 555-563.

Killingsworth, J., Mehany, M.H. & Ladhari, H. 2020. General contractors' experience using off-site structural framing systems. *Construction Innovation*, *21*(1), 40-63.

Kim, J.H., Kim, J.M., Cha, H.S. & Shin, D.W. 2006. Development of the construction waste management performance evaluation tool (WMPET). In *2006 Proceedings of the 23rd International Symposium on Robotics and Automation in Construction, ISARC*, 263-268.

Kong, L., Li, H., Luo, H., Ding, L. & Zhang, X., 2018. Sustainable performance of just-in-time (JIT) management in time-dependent batch delivery scheduling of precast construction. *Journal of cleaner production*, *193*, 684-701.

Krejcie, R. V. & Morgan, D. W. 1970. Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 30(3), 607-610.

Kulatunga, U., Amaratunga, D. & Haigh, R. 2006. Attitudes & perceptions of construction workforce on construction waste in Sri Lanka. *Management of Environmental Quality, 17*(1), 57-72.

Kumar, S. 2016. Improved estimation of population mean in presence of nonresponse and measurement error. *Journal of Statistical Theory and Practice*, *10*, 707-720.

Kurniawan, T.A., Othman, M.H.D., Liang, X., Goh, H.H., Gikas, P., Kusworo, T.D., Anouzla, A. & Chew, K.W. 2023. Decarbonization in waste recycling industry using digitalization to promote net-zero emissions and its implications on sustainability. *Journal of Environmental Management*, 338(1), 1-77.

Laefer, D. 2008. Performance Expectations of Early 20th Century Urban American Building Foundations. *Geosustainability and Geohazard Mitigation*. https://doi.org/10.1061/40971(310)120

Leavy, P. 2017. Research design, quantitative, qualitative, mixed methods, art-based, and community-based participatory research approaches. New York, NY: The Guilford Press.

Leedy, P.D. & Ormrod, J.E. 2010. *Practical research: Planning and design*, 9th edition. Boston.

Li, J., Xiao, F., Zhang, L. & Amirkhanian, S.N. 2019. Life cycle assessment and life cycle cost analysis of recycled solid waste materials in highway pavement: A review. *Journal of Cleaner Production*, *233*(1), 1182-1206.

Liphadzi, N.M. 2022. *Investigating the opportunities and challenges of building information modelling in Construction Waste Management: a comparative study in South Africa* (Doctoral dissertation, University of Johannesburg).

Liu, J., Yi, Y. & Wang, X. 2020. Exploring factors influencing construction waste reduction: A structural equation modelling approach. *Journal of Cleaner Production*, *276*(1), 1-16.

Liwan, S.R., Kasim, N. & Zainal, R. 2013. *Materials Tracking Practices for Inventory Management in Construction Projects.* 1-6.

Lu, W., Webster, C., Peng, Y., Chen, X., & Zhang, X. 2017. Estimating and calibrating the amount of building-related construction and demolition waste in urban China. *International Journal of Construction Management*, *17*(1), 1-12.

Ma, F., Sha, A., Yang, P. & Huang, Y. 2016. The greenhouse gas emission from Portland cement concrete pavement construction in China. *International journal of environmental research and public health*, *13*(7), 632.

Ma, M., Tam, V.W., Le, K.N. & Li, W. 2020. Challenges in current construction and demolition waste recycling: A China study. *Waste Management*, *118*, 610-625.

Mahmood, M. S. & Othman, M.K. 2020. Learning style practices and critical thinking of students in Malaysia. *Universal Journal of Educational Research, 8*(8), 3570-3578.

Manisalidis, I., Stavropoulou, E., Stavropoulos, A. & Bezirtzoglou, E. 2020. Environmental and health impacts of air pollution: a review. *Frontiers in public health*, *8*, 505570.

Mathenjwa, M. 2020. *Challenges faced by main contractors in working with inexperienced subcontractors on construction projects in South Africa*. Master's thesis, University of KwaZulu-Natal, 1-89.

Mbadugha, L. C., Ozumba, A. O. U. & Shakantu, W. M. W. 2021. The need to improve current waste management practices in the area of construction waste reduction. *IOP Conference Series: Earth and Environmental Science*, *654*(1), 1-13.

Mbazima, S.J., Masekameni, M.D. & Mmereki, D. 2022. Waste-to-energy in a developing country: The state of landfill gas to energy in the Republic of South Africa. *Energy Exploration & Exploitation*, *40*(4), 1287-1312.

Mbote, R. P., Kimtai, A. K. & Makworo, M. 2016. An Investigation on the Influence of Factors Causing Material Waste on Construction Cost of Residential Building Frame: A Case of Northern Region of Nairobi. *International Journal of Engineering Research Technology*, *5*(1), 436–447.

Mbote, R. P. & Makworo, M. 2018. Causes and minimization of material waste in construction of residential buildings in Northen Nairobi. *Journal of Engineering Research & Technology*, *7*(8), 1-8.

McNamara, A. J. & Sepasgozar, S. M. E. 2021. Intelligent contract adoption in the construction industry: Concept development. *Automation in Construction*, *122*(1), 1-20.

Meng, M., Wen, Z., Luo, W. & Wang, S. 2021. Approaches and policies to promote Zero-waste City construction: China's practices and lessons. *Sustainability*, *13*(24), 13537.

Mengshoel, A.M. 2012. Mixed methods research – So far easier said than done? *Manual Therapy, 17*(4), 373-375.

Mirtl, M., Borer, E.T., Djukic, I., Forsius, M., Haubold, H., Hugo, W., Jourdan, J., Lindenmayer, D., McDowell, W.H., Muraoka, H. & Orenstein, D.E. 2018. Genesis, goals and achievements of long-term ecological research at the global scale: A critical review of ILTER and future directions. *Science of the total Environment*, *626*, 1439-1462.

Mishra, P., Singh, U., Pandey, C.M., Mishra, P. & Pandey, G. 2019. Application of student's t-test, analysis of variance, and covariance. *Annals of cardiac anaesthesia*, *22*(4), 407-411.

Mohan, Y., Sheoran, U. & Rani, A. 2015. Construction and Demolition Waste Management Advantages of Demolition in Construction. *International Journal of Science and Research, 6*(6), 2612-2614.

Moore T. J. T., Urquhart J. S., Morgan L. K., Thompson M. A. 2012. The effect of spiral arms on star formation in the Galaxy. *Monthly Notices of the Royal Astronomical Society*, *426*(1), 701.

Muhwezi, L., Chamuriho, L. M. & Lema, N. M. 2012. An investigation into materials wastes on building construction projects in Kampala-Uganda. *Scholarly Journal of Engineering Research*, *1*(1), 11-18.

Mulu, K. 2021*. Effect of construction material management on project performance: Case study of Bamacon Engineering PLC*. Master's thesis, St. Mary's University, Addis Ababa.

Musarat, M. A., Alaloul, W. S. & Liew, M. S. 2021. Impact of inflation rate on construction projects budget: A review. *Ain Shams Engineering Journal*, *12*(1), 407-414.

Nagapan, S., Rahman, I. A., Asmi, A., Hameed, A. & Zin, R. M. 2012. Identifying Causes of Construction Waste - Case of Central Region of Peninsula Malaysia. *International Journal of Integrated Engineering, 4*(2), 22–28.

Nanaware, M.R. & Saharkar, U.R. 2017. Application of inventory control technique in construction. *International Journal of Engineering Research and General Science,* 5(4), 1-6.

Nardi, B. 2018. *Doing Survey Research: A Guide to Quantitative Research Methods,* 4th Edition. London.

Nawaz, A., Chen, J. & Su, X. 2023. Factors in critical management practices for construction projects waste predictors to C&DW minimization and maximization. *Journal of King Saud University-Science*, *35*(1), 1-13.

Neuman, W. L. 2014. *Basics of Social Research.* 2nd Edition. Germany, 1-599.

Ng, L. S., Tan, L. W. & Seow, T. W. 2018. Constraints to 3R construction waste reduction among contractors in Penang. *IOP Publishing IOP Conf. Series: Earth and Environmental Science*, *140*(1), 1-10.

Ngcengeni, S. 2020. *Factors influencing sustainable performance in the construction industry in South Africa* (Doctoral dissertation, North-West University (South Africa).

Nguyen, P.H., Cao, Q.K.N. & Bui, L.T. 2022. Energy recovery from municipal solid waste landfill for a sustainable circular economy in Danang City, Vietnam. In *IOP Conference Series: Earth and Environmental Science*, 964(1), 012015.

Njoku, P. O & Edokpayi, J. N. 2023. Estimation of landfill gas production and potential utilization in a South Africa landfill. *Journal of the Air & Waste Management Association*, *73*(1), 1-14.

Nulty, D.D. 2008. The adequacy of response rates to online and paper surveys: What can be done? *Assessment & Evaluation in Higher Education, 33*(3), 301-314.

Nyika, J. M., Onyari, E. K., Mishra, S. & Dinka, M. O. 2019. *Waste Management in South Africa*, 328-351. DOI: 10.4018/978-1-7998-0198-6.ch014.

Nzima, L. & Ayesu-Koranteng, E. 2021. Construction waste management practices in the construction industry. *Journal of Natural and Applied Sciences*, *5*(1), 39-55.

Oke, A., Aigbavboa, C., Aghimien, D. & Currie, N. 2019. Construction Professionals' Perception of Solid Waste Management in the South African Construction Industry. *Construction Professionals Perception of Solid Waste Management*, *788*(1), 496–505.

Okwesili, J. & Iroko, C. 2016. Urban solid waste management and environmental sustainability in Abakaliki Urban, Nigeria. *European Scientific Journal*, *12*(23), 1-29.

Omran, M.M., Farid, K., Emran, T.M. & Atallah, A.A. 2011. Fibro-a score as a simple and useful non-invasive test for predicting significant liver fibrosis in chronic hepatitis C patients. Arab J Gastro-enterol, 74–79.

Onamade, A. O., Asaju, O. A., Adetona, O. & Alagbe, O. 2022. Building Industry Professional Attitude Towards Construction and Demolition Waste Hazards in Lagos Metropolis, Nigeria. *Journal of Environmental Science,* 16(11), 26-31.

Osmani, M., Glass, J. & Price, A.D. 2008. Architects' perspectives on construction waste reduction by design. *Waste management*, *28*(7), 1147-1158.

Pallant, J., 2020. *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. Routledge.

Park, J. & Tucker, R. 2017. Overcoming barriers to the reuse of construction waste material in Australia: A review of the literature. *International Journal of Construction Management*, *17*(3), 228-237.

Park, Y.S., Konge, L. & Artino Jr, A.R. 2020. The positivism paradigm of research. *Academic medicine*, *95*(5), 690-694.

Pawlikowski, P., Rico, N. & Van Sell, S. 2018. Positivism: A concept analysis.

Pereira, V., Hadjielias, E., Christofi, M. & Vrontis, D. 2023. A systematic literature review on the impact of artificial intelligence on workplace outcomes: A multi-process perspective. *Human Resource Management Review*, *33*(1), 100857.

Perera, A.T.D., Coccolo, S. & Scartezzini, J.L. 2019. The influence of urban form on the grid integration of renewable energy technologies and distributed energy systems. *Scientific reports*, *9*(1), 17756.

Pheng, L. S. & Hou, L. S. 2019. The Economy and the Construction Industry: A Study at the Firm Level. *Construction Quality and the Economy*, 21-54, doi: 10.1007/978-981-13-5847-0_2.

Pires, A. & Martinho, G. 2019. Waste hierarchy index for circular economy in waste management. *Waste Management*, 95(1), 298-305.

Pituch, K.A. & Stevens, J.P. 2015. Assumptions in MANOVA. In *Applied multivariate statistics for the social sciences*. Routledge. 219-264.

Polat, G., Damcia, A., Turkoglua, H. & Gurgunb, A.P. 2017. Identification of root causes of construction and demolition (C&D) waste: the case of Turkey. *Procedia Engineering, 196*(1), 948- 955.

Ponnada, M.R. & Ponnada, K. 2015. Construction and Demolition Waste Management – A Review. *International Journal of Advanced Science and Technology, 84*(1),19-46.

Portny, J.L. & Portny, S.E. 2022. *Project management for dummies*. John Wiley & Sons.

Purchase, C. K., Zulayq, D.M., Brien, B. T., Kowalewski, M., Berenjian, A., Tarighaleslami, H. & Seifan, M. 2021. Circular economy of construction and demolition waste: A literature review on lessons, challenges and benefits. *Materials, 15*(1), 1-88.

Rabea, A. Al. 2016. Construction waste management, and how it can preserve a healthy environment. Doi: https://doi.org/10.13140/RG.2.1.3850.2162

Revell, A. & Blackburn, R. 2007. The business case for sustainability? An examination of small firms in the UK's construction and restaurant sectors. *Business strategy and the environment*, *16*(6), 404-420.

Robinson, S.B. & Leonard, K.F. 2018. *Designing quality survey questions*. Sage publications.

Romero-Hernández, O. & Romero, S. 2018. Maximizing the value of waste: From waste management to the circular economy. *Thunderbird International Business Review*, *60*(5), 757-764.

Rooshdi, R.R.R.M., Abd Majid, M.Z., Sahamir, S.R. & Ismail, N.A.A. 2018. Relative importance index of sustainable design and construction activities criteria for green highway. *Chemical engineering transactions*, *63*, 151-156.

Rose, C.M. & Stegemann, J.A. 2018. From waste management to component management in the construction industry. *Sustainability*, *10*(1), 229.

Ruparathna, R. & Hewage, K. 2013. Review of Contemporary Construction Procurement Practices. *Journal of Management in Engineering, 31*(3), 1-13.

Ryan, G., 2018. Introduction to positivism, interpretivism and critical theory. *Nurse researcher*, *25*(4), 41-49.

Saadi, N., Ismail, Z. & Alias, Z., 2016. A review of construction waste management and initiatives in Malaysia.

Saah, P. 2021. The impact of small and medium-sized enterprises on the economic development of South Africa. *Social Sciences Journal, 24*, 549-561.

Saidu, I. & Shakantu, M. 2016. Management of material waste and cost overrun in the Nigerian construction industry.

Sakhare,V.D. & Patil, G.S. 2019. Construction Equipment Monitoring: By Using Relative Important Indices (Rii) Analysis. *International Research Journal of Engineering and Technology (IRJET)*, *6*(11), 261-263.

Salkind, N. J. 2006. *Tests & measurement for people who (think they) hate tests & measurement*. Thousand Oaks, CA: Sage Publications.

Saunders, M., Lewis, P. & Thornhill, A. 2011. *Research methods for business students.* 5th ed. Harlow: Prentice Hall Financial Times.

Sekaran, U. & Bougie, R. 2010. *Research methods for business: A skill building approach.* 5th ed. United Kingdom: John Wiley & Sons Ltd.

Sev, A. 2009. How can the construction industry contribute to sustainable development? A conceptual framework. *Sustainable Development*, *17*(3), 161-173.

Sharma, C. 2017. Pros and cons of different sampling techniques. *International Journal of Applied Research*, *3*(7), 749-752.

Shooshtarian, S., Caldera, S., Maqsood, T. & Ryley, T. 2020. Using Recycled Construction and Demolition Waste Products: A Review of Stakeholders' Perceptions, Decisions, and Motivations. *Recycling*, *5*(1),1-16.

Siddiqua, A., Hahladakis, J. N. & Al-Attiya, W. A. 2022. An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. Environmental Science and Pollution *Research, 29*(1), 1-23.

Siregar, A. M. & Kustiani, I. 2021. Contractors' perception on construction waste management case study in the City of Bandar Lampung. *The International Conference Research Collaboration of Environmental Science*, 245(1), 1-5.

Slack, R.J., Gronow, J.R. & Voulvoulis, N. 2005. Household hazardous waste in municipal landfills: Contaminants in leachate. *Science of the total environment*, *337*(1-3), 119-137.

Solanke, B.H. 2015. *Effective strategy for construction materials procurement during construction towards the enhancement of sustainable building production in Western Cape, South Africa* (Doctoral dissertation, Cape Peninsula University of Technology).

Song, Y., Wang, Y., Liu, F. & Zhang, Y. 2017. Development of a hybrid model to predict construction and demolition waste: China as a case study. *Waste Management*, *59*(1), 350-361.

Sormunen, P. & Kärki, T. 2019. Recycled construction and demolition waste as a possible source of materials for composite manufacturing. *Journal of building engineering*, *24*, 100742.

Spišáková, M., Mésároš, P. & Mandičák, T. 2021. Construction waste audit in the framework of sustainable waste management in construction projects case study. *Buildings*, *11*(2), 61.

Statistics South Africa. 2010. Statistical Release P0441 Gross Domestic Product Fourth Quarter: 2009. Pretoria, South Africa: Stats SA. Available at: www.statssa.gov.za.

Stoker, P., Tian, G. & Kim, J.Y. 2020. Analysis of variance (ANOVA). In *Basic Quantitative Research Methods for Urban Planners*. Routledge. 197-219.

Stubbs, K. 2021. Reimaging the potential of waste. *Resource*, *23*(1), 28-30.

Suresh, K.P. & Chandrashekara, S. 2012. Sample size estimation and power analysis for clinical research studies. *Journal of Human Reproductive Sciences, 5*(1), 7-13.

Sweis, G. J., Hiari, A., Thneibat, M., Hiyassat, M., Abu-Khader, W. & Sweis, R. J. 2021. Understanding the Causes of Material Wastage in the Construction Industry. *Jordan Journal of Civil Engineering*, 15(2), 1-14.

Tafesse, S., Girma, Y. E. & Dessalegn, E. 2022. Analysis of the socio-economic and environmental impacts of construction waste and management practices. *Heliyon*, 8(3), 1-10.

Tamminen, K.A. & Poucher, Z.A., 2020. Research philosophies. In *The Routledge international encyclopedia of sport and exercise psychology* (pp. 535-549). Routledge.

Tam, V. W. Y., Soomro, M., Evangelista, A. C. J. 2018. A review of recycled aggregate in concrete applications. *Construction and Building Materials*, *172*(1), 272-292.

Udawattaa, N., Zuo, J., Chiveralls, K., & Zillante, G. 2015. Improving waste management in construction projects: An Australian study. *Resources, Conservation and Recycling*, *101*(1), 73–83.

Van Acker, J., Van den Bulcke, J., Forsthuber, B. & Grüll, G. 2023. Wood preservation and wood finishing. In *Springer Handbook of Wood Science and Technology.* Cham: Springer International Publishing, 793-871.

Van Wyk, L. 2014. Towards net-zero construction and demolition waste. In: *Green Building Handbook, South Africa: The Essential Guide, 6*(1), 132-141.

Von Blottnitz, H., Virag, D., Wiedenhofer, D. & Haas, W. 2022. An Economy-wide Material Flow Analysis to Develop Circular Economy Indicators for South Africa. Reference report, 1-53.

Walliman, N.S. & Walliman, N. 2005. *Your research project: A step-by-step guide for the first-time researcher*. Sage.

Wang, Q., Chen, L., Hu, R., Ren, Z., He, Y., Liu, D. & Zhou, Z. 2020. An empirical study on waste generation rates at different stages of construction projects in China. *Waste Management & Research*, *38*(4), 433-443.

Williams, J. 2023. Circular cities: Planning for circular development in European cities. *European Planning Studies*, *31*(1), 14-35.

Wu, C-L., Fang, D-P., Liao, P-C., Xue, J-W., Li, Y. & Wang, T. 2015. Perception of corporate social responsibility: The case of Chinese international contractors. *Journal of Cleaner Production*, 107(1), 185-194.

Yakubu, Y. & Zhou, J. 2017. Novel approach to quantify municipal solid waste management hierarchy based on analytical hierarchy process. *International Journal of Environmental Science and Technology*, *6*(1),1897-1908.

Yang, B., Song, X., Yuan, H. & Zuo, J. 2020. A model for investigating construction workers' waste reduction behaviors. *Journal of Cleaner Production*, *265*, 121841.

Yeheyis, M., Hewage, K., Alam, M.S., Eskicioglu, C. & Sadiq, R. 2013. An overview of construction and demolition waste management in Canada: A lifecycle analysis approach to sustainability. *Clean technologies and environmental policy*, *15*, 81-91.

Yong, A.G. & Pearce, S. 2013. A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in quantitative methods for psychology*, *9*(2), 79-94.

Yu, Q. & Li, H. 2021. Life cycle environmental performance of two restaurant food waste management strategies at Shenzhen, China. *Journal of Material Cycles and Waste Management*, *23*(2), 826-839.

Yuan, H. 2017. Barriers and countermeasures for managing construction and demolition waste: A case of Shenzhen in China. *Journal of Cleaner Production*,*157*(1), 84-93.

Zaman, A.U. & Lehmann, S. 2011. Urban growth and waste management optimization towards 'zero waste city. *City, Culture and Society*, *2*(1), 177-187.

Zaman, U., Abbasi, S., Nawaz, S. & Siddique, M. S. 2020. Linking Sustainability Management and Success in Construction Projects: Moderating Influence of High-Performance Work Systems. *Pakistan Journal of Commerce and Social Sciences,14*(3), 661-684.

Zhao, X. 2021. Stakeholder-Associated Factors Influencing Construction and Demolition Waste Management: A Systematic Review. *Buildings*, 11(1), 1-22.

Zorpas, A.A. 2020. Strategy development in the framework of waste management. *Science of the total environment*, *716*, 137088.