AN INVESTIGATION OF WATER CONSEVATION DURING THE CONSTRUCTION OF HOUSING PROJECTS IN CAPE TOWN, SOUTH AFRICA

by

AZOLA AGRIENETTE MAYEZA

Thesis is submitted in fulfilment of the requirements for the degree

Master of Construction

In the Faculty of Engineering and the Built Environment

at the

Cape Peninsula University of Technology

Supervisor: Dr Xolani Nghona

Bellville

April 2024

DECLARATION

I, Azola Agrienette Mayeza, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

……………………………………… 06 November 2024 ……………………………..

Signed **Date**

ABSTRACT

Water scarcity poses a critical challenge to sustainable development, particularly in regions grappling with its profound implications. In response to this challenge, this study undertook an in-depth exploration into water conservation practices during the construction of housing projects in Cape Town, South Africa. The primary objective was to identify solutions that could alleviate the strain on freshwater resources within the construction industry. The investigation unfolded across various dimensions, from pinpointing reusable water applications to highlighting innovative practices and emphasising water-efficient methodologies.

The study findings showcase a promising path forward. Reusable water, identified as a viable substitute in specific construction activities such as dust suppression, bricklaying and concrete curing, emerges as a key player in mitigating water consumption. The study champions the use of recycled water, affirming its practicality without compromising construction quality. Innovative solutions, including the adoption of curing agents and the implementation of grey water for non-potable uses, signify the industry's responsiveness to water scarcity challenges.

The water-efficient practices embraced by the construction sector further underscore its commitment to sustainability. From recycled water usage to the implementation of misting and atomising systems for dust suppression, the industry has demonstrated a proactive stance. These practices not only reduce water wastage but also align with broader ecological goals.

Crucially, this research extends beyond mere identification; it proposes a roadmap for the industry's future. Recommendations encompass educational initiatives, technological adoption and collaborative efforts to create a holistic approach to water conservation. By illuminating the nexus between responsible water management and construction practices, this study contributes to the evolving discourse on sustainable development, offering practical insights for not only Cape Town but also other regions facing similar water challenges.

ACKNOWLEDGEMENTS

Praise be to God in the name of our Lord Jesus Christ who is the Lord of my life for carrying me from the beginning of this journey and bringing me this far. I give all the glory to Jesus for granting me the wisdom, guidance, patience and strength that I needed to complete this thesis.

This thesis is the outcome of the combined efforts, support and contribution of numerous people who deliberately or unknowingly assisted in its completion.

I express my profound and immense gratitude to the following:

- My mother, Tryphina Nomakosi Mayeza, for her support and countless sacrifices towards giving me a better future and instilling the importance of education as a key to success, echoing the great Nelson Mandela.
- My husband, Sivuyile Ndungane, for his love and amazing support towards the completion of this thesis and fulfilling all my dreams.
- My siblings, Vuyokazi, Zolisa, Asanda and their families for their unwavering support.
- My supervisor, Dr Xolani Nghona, for his guidance, patience, encouragement and valuable support towards the successful completion of this research project.
- I will never forget to mention the support given by my Spiritual family – Faith Champions Church family. My pastor, Apostle Joseph Kwadwo Asomah, Mama Siphe Xana-Asomah, the leaders and the whole congregation of FCC for never missing an opportunity to pray for me and encourage me throughout this research project.
- The Head of the Department of Construction Management and Quantity Surveying, Ms Toni Stringer, for her incomparable assistance throughout this research project.
- The lecturers in the Department of Construction Management and Quantity Surveying, especially Mr Luviwe Bikitsha for his support and contribution to the successful completion of this study.
- Finally, I thank the Cape Peninsula University of Technology (CPUT) and Dean of the Faculty of Engineering and Built Environment for granting me the opportunity to complete this degree.

DEDICATION

This thesis is dedicated to my late father, Reverend W S Mayeza, who had a great passion for education. He loved reading and showed his love for studying and teaching first as a professional teacher and later when he became a minister of Christ teaching the word of God to people and leading them to Christ. He would be so proud to know that I have adopted his love for reading and eventually followed in his footsteps.

List of Graphs

List of Tables.

List of Diagrams

Table of Contents

Key Terms

Cape Town; conservation measures; construction of housing projects; inefficient water usage; sustainability; water conservation; water conservation activities; water-conservation behaviour; water conservation strategies; water shortage; water waste management.

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Background to the problem

The scale of construction in South Africa is growing, many buildings are under construction and cities are expanding. The demand for urban housing is at an all-time high, with over 2.7 million low-cost government houses already having been built within the past 15 years, and yet the housing backlog still remains extreme (Ernest Harsch, n.a) and is estimated at 2.1 million (Gerber, 2018). In 2021, the housing shortage reached 3.7 million and was estimated to be growing at 178,000 annually (CAHF, 2021).

To meet the increasing housing demand, more houses must be built, a practice that also will automatically increase the demand for natural resources such as land and water. The construction sector, in common with all industries, must adhere to the Sustainable Development Goals (SDGs) (UN website, 2023). The objective of SDGs is to guide existing companies and countries as to how they can implement their strategies and measures and manage their contribution to the SDGs. Some SDGs items that are particularly relevant to the construction sector include the reduction of wasteful water consumption, CO_2 emissions caused by existing buildings, among others. As a result, housing construction must be conducted in the most sustainable way possible in order to preserve the natural environment and, at the same time, provide affordable housing with access to clean pipe-born water, sewage disposal, sanitation, transport, education, healthcare and child development (Eziyi & Egidario 2015). However, a recent study conducted by Vawda & Hugo, (2022) shows that in South Africa “the provision of low-cost housing struggles with high levels of energy wastage, inefficient water use and high carbon footprints”.

Sustainability encompasses various dimensions, ensuring a better quality of life for present and future generations (Kuhlman & Farrington, 2010). It involves achieving social progress, effective environmental protection, prudent resource use and maintaining economic growth and employment levels. Mollenkamp (2023) defines sustainability as the ability to maintain or support a process continuously over a period of time, with a purpose of preventing depletion of natural or physical resources for future purposes. Essentially, sustainability aims to balance human needs with environmental preservation, fostering harmony between society, the economy and the ecosystem.

Sustainable construction entails the creation and responsible management of a healthy built environment, emphasizing resource efficiency and ecological principles (Zabihi et al., 2012).

This involves minimizing negative impacts and maximizing positive ones, achieving a balance across environmental, economic and social performance (ibid). Key objectives include resource and energy efficiency, pollution prevention and remaining in harmony with the environment through integrated approaches (ibid).

The construction industry's sustainability performance exhibits a mixed picture. While there have been advancements in adopting sustainable practices such as energy-efficient design and eco-friendly materials, challenges persist in other areas including waste management and carbon emissions (Mfon, Bessie, & Ndifreke, 2024). Efforts to integrate sustainability into construction processes are underway but broader implementation and adherence to sustainable principles are needed for substantial progress to be achieved (ibid).

Moreover, the Constructing Excellence (2004) offers a comprehensive definition of sustainable construction: “sustainable construction is all about ensuring a better quality of life for everyone, now and for generations to come”, through:

a) Social progress which recognises the needs of everyone

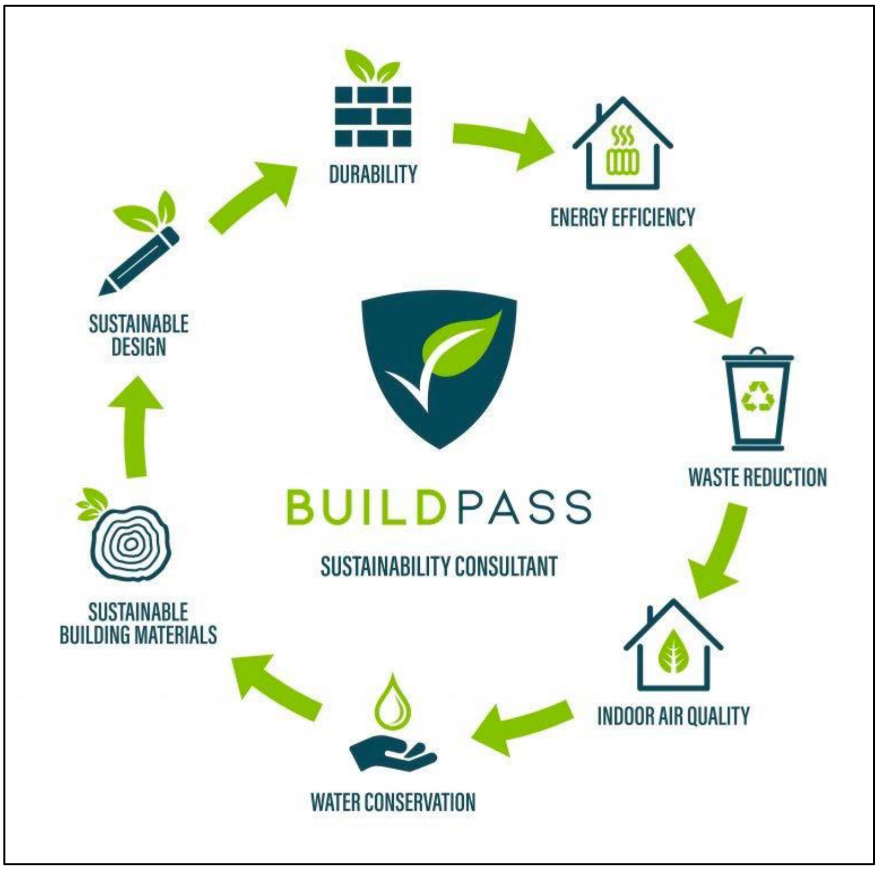
b) Maintenance of high and stable levels of economic growth and employment, whilst

c) Protecting and, if possible, enhancing the environment, and

d) Using natural resources prudently.

According to Sourani and Sohail (2011, p.8), despite many claims regarding the benefits that sustainable construction can bring, sustainability still is not the primary focus in the construction industry. This situation is still the case because recently, Musir et al. (2022 p.3) argued that “there is a gap of knowledge and awareness on sustainable construction and its practices”. Among the four aforementioned factors, this study focuses on the prudent use of natural resources (e.g., water). This is because South Africa is considered a water-scarce country and the increasing demand for water use can eventually lead to a scenario of excess demand over supply. This scenario of excess demand for water use can be avoided by the adoption of sustainability measures by moderating the patterns of water demand and, at the same time, supporting innovative ideas of introducing new sources of water supply. In consideration of the fact that water is a scarce but a vital resource, issues concerning water conservation should also be considered as vital. According to the diagram below there are seven principles of sustainable construction, however, this study focuses on one of those principles:

Diagram 1: 1 Sustainable Construction



Source: Sadler, (2021)

Although a sustainable construction design phase is imperative, according to the seven principles of sustainable construction document, one of the ways to obtain water conservation on the building site during the construction phase is:

“To help reduce your waste at your building site, make sure to use low impact materials that are sustainability sourced and reused from other projects as well as sustainable recycling at every stage of the construction process” (Sadler, 2021).

This study focuses on water use and water conservation during the construction phase of housing projects. As mentioned above, water is one of the most vital resources in all aspects of human existence, including housing construction. Water is required at every stage of housing construction, in the preparation of mortar, mixing of cement concrete, for curing work, cleaning tools and equipment and so forth. In a broader sense, the continuing availability of freshwater is crucial for the construction industry. It is also critical for the continuity of modern civilisation, for increased food security, energy security, poverty reduction, economic growth, conflict reduction, climate change adaptation and biodiversity. This threat makes it vital that all stakeholders, including the construction industry, enact measures to conserve water use.

Water shortage is experienced globally at an unprecedented rate due to overuse and ever-increasing demand (Young & Loomis, 2014).

1.2 Problem Statement

South Africa is not immune to the water shortage crisis (WWF, 2017) and the City of Cape Town was reportedly one of the areas severely affected by water shortage between 2015 and 2018. While the construction projects are perceived to be water-intensive in usage (Ramachandran, 2004), with a record of excessive water consumption (Waidyasekara & Rameezdeen, 2016) water conservation particularly during the construction of housing projects is yet to be fully investigated. While Musir et al. (2022, p.3) argue that “there is a gap of knowledge and awareness on sustainable construction and its practices”, a study by Moghayedi et al. (2023, p. 2) shows that in South Africa, “the provision of low-cost housing struggles with inefficient water usage”. The usage of water during housing construction is high and there is a lot of water being wasted during the building process, this study explores the current practices of efficient water use and methods of conservation currently in practice during the construction phase of housing projects in Cape Town.

1.3 Research Hypothesis

The research hypotheses to be tested in this study are:

a) **H1**: There are guidelines for water use in the construction of housing projects in South Africa.
b) **H2**: Construction sites primarily obtain water from municipal water sources during the construction of housing projects in Cape Town.
c) **H3**: Water conservation methods are currently being implemented to some extent in the construction of housing projects in Cape Town.
d) **H4**: The identification of challenges in implementing sustainable water conservation methods during housing construction in Cape Town will provide insights into areas where specific recommendations can be developed to improve water conservation practices.
e) **H5**: The investigation of strategies for water conservation implemented during the construction of housing projects in Cape Town will reveal the extent to which water shortage challenges influence changes in water usage practices and the adoption of water-efficient methods.

1.4 Research Aim

This research study's main purpose is to investigate water conservation practices in the construction phase of housing projects in Cape Town in order to identify the sources of water use, methods and practices of water conservation and offer solutions that can be adopted during this phase to conserve water. In short, the study explores the factors of water use, the methods of efficient water use and the mechanisms of water conservation in housing construction in Cape Town.

1.5 Objectives

a) To investigate the guidelines for freshwater use in the construction of housing projects in Cape Town.
b) To establish the sources of water used in housing construction projects in Cape Town.
c) To examine existing water conservation methods in the construction of housing projects in Cape Town.
d) To investigate the challenges encountered in implementing sustainable water conservation methods during the construction of housing projects in Cape Town.
e) To explore strategies for water conservation employed during the construction of housing projects in Cape Town, including an examination of the current water usage practices, challenges faced and their potential solutions in the construction industry.

1.6 Expected outcome

It is anticipated that this study will reveal the significance of efficient water use in housing construction as a major contributor to water conservation and the prevention of a water crisis problem. The study further aims to contribute to the body of literature on water use in housing construction and it is envisaged that the findings of this study will contribute to theory and practice in this field.

a. Theory Contribution

The findings of this study are expected to contribute significantly to theoretical advancements in the field of water conservation within housing construction. Firstly, the study provides empirical evidence regarding the effectiveness of various water conservation strategies in construction activities in Cape Town. By identifying specific activities during which reusable water can be employed, the study adds to existing theoretical frameworks by elucidating practical applications of water conservation principles. Additionally, the study's exploration of innovative practices, such as the use of curing agents and grey water for ablution facilities, expands theoretical understanding by showcasing emerging trends and alternatives in sustainable construction practices. These contributions will enrich theoretical discourse by offering insights into the feasibility and effectiveness of different approaches to water conservation in housing construction.

b. Practice Contribution

On the practical front, the findings of this study hold significant implications for industry practitioners, policymakers and construction stakeholders. Firstly, the identification of specific construction activities suitable for employing reusable water provides practical guidelines for construction companies aiming to adopt sustainable practices. By highlighting opportunities for reducing freshwater consumption without compromising construction quality, the study seeks to equip practitioners with actionable insights to effectively implement water conservation measures. Moreover, the study's recommendations for educational initiatives, training programmes and collaboration with government initiatives will offer practical strategies for fostering a culture of water conservation within the construction industry. These contributions bridge the gap between theory and practice by offering tangible recommendations for integrating sustainable water management practices into construction processes, the implementation of which will facilitate real-world impact.

1.7 Significance

The significance of this study is to draw attention to the problem of water conservation in the construction of housing projects in Cape Town. The study relies on the findings to make recommendations to both policy makers and stakeholders involved in housing construction on the best methods of efficient water use during construction stage.

1.8 Scope of Study

The study analyses the perceptions of stakeholders in housing construction towards methods of efficient water use during the construction phase. This study was conducted only in the city of Cape Town in South Africa’s Western Cape Province. Cape Town has a housing backlog of some 365,000 houses (Human, 2022) that the city’s municipality intends to build.

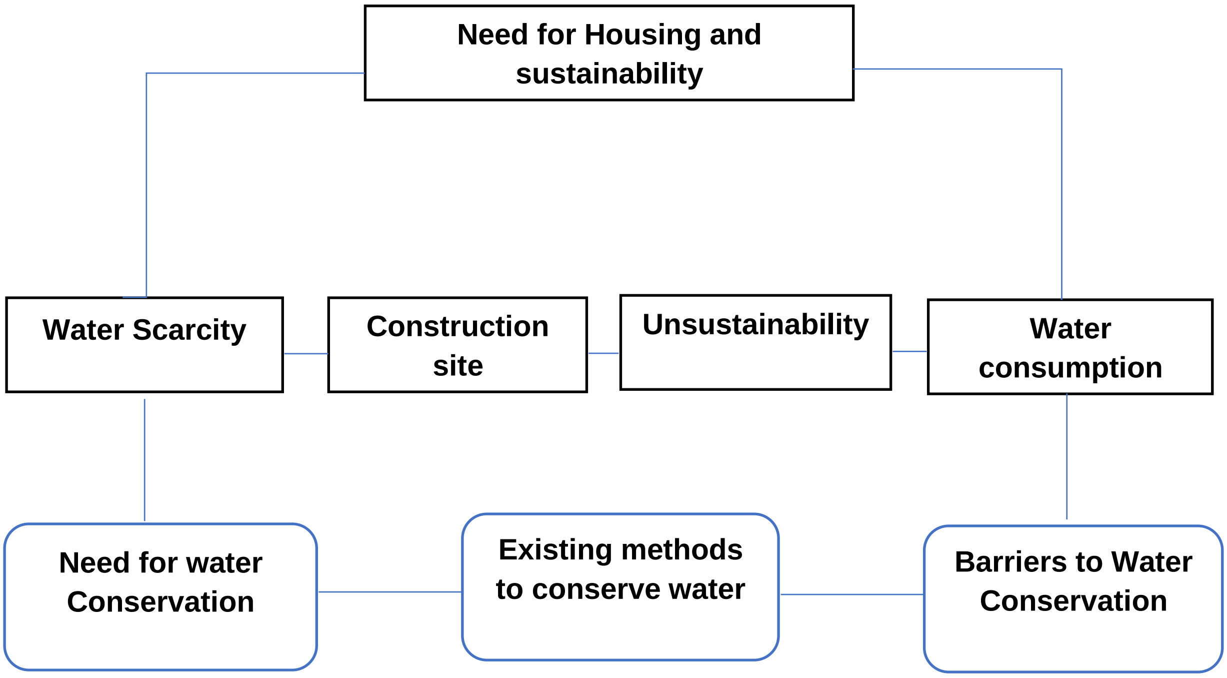
1.9 Conceptual Framework

The major concern of this study was to investigate the process of water use and water conservation during the construction phase of housing projects, with a focus on the means of sustainable water use and conservation methods implemented in housing construction. There are a number of factors contributing to the need for water conservation, including economic factors, development factors, population growth, urbanization and climate change – all of which have contributed to the water shortage. Two of the greatest challenges facing the present century are that of water shortage and global warming. Due to the ever increasing shortage of water as a result of the high demand for its use, there is a crucial need for all stakeholders to adopt new methods of water conservation and the sustainable use of fresh water.

Human activities such as construction, deforestation, agricultural and mining are the leading causes of water scarcity. The task of addressing water scarcity requires an effective application of values and the results of the sustainability actions that the current management theories have developed and prescribed. According to specialists Blignaut and Heerden (2009), South Africa's unallocated water resources have dwindled to precariously low levels and, consequently, it is likely that water demand will exceed water supply.

However, the above perceived crisis can be avoided by adopting water conservation methods. Water conservation is related to water demand management, and strives to combine economic, behavioural, technological and educational means to achieve the general objective of lowering water consumption to reduce the need for water usage that may be economically, socially and environmentally costly (Brooks, 2006; Tate. 1993).

Diagram 1.2: Conceptual Framework



Source: Azola, 2024

The theoretical framework presented above addresses the relationships in housing construction and its impact on water use. This study explores the further the use of water efficiency and water conservation methods as well as alternative sources, including those of ‘reduce, reuse and recycle’, while identifying the barriers to their use in housing construction.

1.10 Overview of Research Methodology

- **Questionnaire design**: The design of the questionnaire followed a Likert scale format, whereby the participants were asked to indicate the options that best suited their interpretation of the question.
- **Sampling Methods**: A simple random sampling approach was employed to select participants from stakeholders particularly involved in the construction of housing projects.
- **Data collection process**: Both secondary and primary data was used. Secondary data involved the gathering information from literature sources, while primary data was collected by the use of a questionnaire tool, which was distributed to the selected sample of respondents.
- **Data Analysis:** The study used a mixture of quantitative and qualitative methods to analyse data. This involved the use of various statistical techniques to analyse numerical data as well as systematic methods for categorical data.

- **Reliability and Validity**: The researcher ensured reliability and validity through selection of trusted professionals who were capable of providing effective and relevant information regarding the research objectives.

1.11 Ethical Considerations

Based on the internationally acceptable standards, the identities of the selected participants – employees of government departments and constructions companies, stakeholders and professionals – are not included in the research instruments. Therefore, all participating individuals and organisations remained anonymous. No payment was made to people who participated in the study and quality assurance was performed.

1.12 Limitations

This research study was limited to the construction phase in public sector housing projects in Cape Town, South Africa. The study area will be limited to the following themes of the literature review:

- Water scarcity
- Guidelines for freshwater use
- Water Conservation and Efficient Use of Water
- Barriers to Water Conservation.

1.13 Assumptions

It was assumed that participants from the selected construction companies would willingly participate and provide relevant information necessary for this study.

1.14 Definition of Key Terms

Construction Industry: Construction industry refers to many concepts including the survey, design, construction and maintenance after completion of construction (Wu et al., 2019).

Housing Construction: Housing construction encompasses a broad set of relationships between house builders, financier(s), developers and the final user (Hayward, 2012).

Water use: Water use refers simply to the use of water for human and animal activities such as agriculture, industry, energy production and households, plus for stream uses such as fishing, recreation, transportation and waste disposal (UN, 1997).

Water scarcity: Water scarcity refers to the lack of abundance or non-abundance of water supply, that is expressed as the ratio of human water consumption to the available water supply in a given area (Schulte, 2014).

Water Conservation: Water conservation refers to measures of water preservation, control and development of water resources, both surface and groundwater and prevention of pollution (United Nations, 1997).

Sustainability of Water Use: Sustainability of water use refers to limiting the wasteful use of freshwater in order to meet various socioeconomic and environmental needs (Carter & Moir, 2012).

1.15 Chapter outline

The chapter outline provides the main sections of each chapter:

Chapter 1: The problem and its setting – this chapter introduces the background, problem statement, research questions and objectives, the significance, the assumptions, limitations, and ethical statement.

Chapter 2: Literature review – this chapter reviews on the need for housing and sustainability, water scarcity and water usage in the construction of housing projects in Cape Town, and methods of efficient water use and conservation during housing construction.

Chapter 3: Research Methodology – the research design and methodology are discussed in more detail. The study used a mixed-method of quantitative and qualitative research to collect and analyse data. The following issues are also discussed: research strategy, sampling technique, sample size, methods of data collection and reliability and validity.

Chapter 4: Data Collection and Analysis – this chapter presents the findings derived from the various demographic aspects of the study participants, their roles and experiences in the construction industry. An in-depth analysis of the collected data is also provided.

Chapter 5: Discussion of Findings – this chapter discusses the findings based on an in-depth analysis of the collected data.

Chapter 6: Conclusions and Recommendations – this chapter concludes the study, highlights the limitations, recommends further study areas to be investigated and provides the summary of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter provides a survey of relevant books and scholarly articles of the key subjects in this research. It includes a summary of theories and concepts put forward by other scholars and a critical evaluation of these works in relation to the research problem being investigated. This chapter builds on the key terms of this study and includes a review of the construction of housing projects, the conservation and efficient use of water; the barriers to water conservation and its efficient use and the consequences of a water crisis.

2.1 Sustainable and Sustainable Housing Construction

Housing construction plays a huge role in the development of society for various reasons, such as determining the quality of life, comfort, security and health. The demand for housing occurs at an ever-increasing rate (Aalberts, 2015) as a result of the expanding population in urban areas. This fact has contributed to the housing crisis (Aalberts, 2015; Potts, 2020) and the pressure on governments and all stakeholders involved in the construction of housing projects. Smith (2018) suggested that in order to meet this global housing demand, there is a need to build approximately two billion homes before the end of the 21st century.

However, it is important to also consider the need for the sustainability of development activities, such as that of ensuring that a better quality of life for everyone is upheld now and for future generations. Sustainability in housing construction means focusing on energy conservation and environmental protection among other factors. The purpose of this process is to ensure the provision of affordable and sustainable housing. Mitlin and Satterthwaite (1996) describe sustainable housing as:

shelter that is healthy, safe, affordable and secure within a neighbourhood with provision of piped water, sanitation, drainage, transport, healthcare, education and child development. It is also a home protected from environmental hazards, including chemical pollution. Also important are to meet needs related to people’s choice and control, including homes and neighbours which they value and where their social and cultural priorities are met.

- (OECD, 2021) defined sustainability in construction as: “the creation and responsible management of a healthy built environment based on resource efficient and ecological principles". The key issues highlighted above are the need for affordable and sustainable housing construction. In order to ensure the provision of such housing, identified four key requirements as follows (OECD, 2021):

- social progress that recognizes the needs of everyone,
- effective protection of the environment,
- prudent use of natural resources and
- maintenance of high and stable levels of economic growth and employment.

Furthermore, for sustainable buildings to be upheld it is necessary to ensure:

- resource efficiency,
- energy efficiency (including greenhouse gas emissions reduction),
- pollution prevention (including indoor air quality and noise abatement),
- harmonization with environment (including environmental assessment) and
- integrated and systemic approaches (including environmental management systems).

Considering that water is a non-renewable resource, the case for sustainability arises. Water sustainability requires the adoption of water conservation methods. Stakeholders in the construction industry, such as architects, surveyors, engineers, project managers and other professionals who are responsible for making decisions, should ensure they adopt methods of sustainable water use throughout the different stages of a housing construction project (Xing et al., 2007).

The construction industry contributes significantly to the challenges of water shortage as well as environmental degradation. Shen, Zhang, Zhang, Huang and Liu (2007) argue that activities happening during the construction stage are closely linked to environmental impacts, including the generation of waste and pollution. Baxter et al. (2004) also stated that the impact of a housing project includes economic, environmental, natural resources consumption and social characteristics. Xing et al. (2009) argued that water, fossil fuels and land are the most important natural resources when considering a projects' sustainability assessment.

In addition, the construction industry is also notorious for its poor water management practices, particularly the management of water wastage (Waidyasekara & Lalith De Silva, 2017). Water is not regarded or treated as a material of civil construction (Camilla et al., 2015). According to Neto (2013), "this situation can be observed in compositions of costs of engineering services that do not include the water as an input of current activities". Camilla et al. (2015), points out some of the activities that use water include compression of landfill, manufacture of concrete and mortar, curing of concrete, testing for waterproofing, latex painting and cleaning.

Despite the growing need for the construction industry to adopt principles of sustainability in their operations, water management continues to be a neglected area (Walton et al., 2005; Xing et al., 2007). The amount of water used in the construction industry is yet to be investigated but such research is evidently a necessity. Aigbavboa, Ohiomah and Zwane (2017) and Wu et al. (2019) noted that the construction industry is one of the major consumers of water; however, very few studies have been published linking this fact with water scarcity. So far efficient water use during housing construction has been given a low priority (Waylen et al., 2011). There is an inadequate appreciation of the significance of water scarcity in construction (Hawkins, 2013). The shortage of freshwater faced in South Africa calls for further research into the methods of water conservation that can help to preserve water resources. This study seeks to explore current practices, the possibility of water use efficiency and methods of conservation relevant to the construction operations.

2.2 Water scarcity

The problem of water scarcity in South Africa is exacerbated by droughts and the demands associated with population growth (Nhlanhla, 2020). South Africa is ranked as one of the 30 driest countries in the world with an average rainfall of about 40% less than the annual world average rainfall (Gerbi, 2017). The state of water storage across the country was estimated at 64.3% of the normal full supply at that time. KwaZulu-Natal was sitting at 57% while Hazelmere Dam, Goedetrouw Dam, Hluhluwe Dam and Klipfontein Dam were at critical levels. According to a government report on national water security, an estimated 6 500 stand-alone rural communities mostly situated in KwaZulu-Natal, Mpumalanga, Limpopo and North West provinces experienced water shortages (Matshediso, 2015). As population, urbanization and the effects of climate change continue to grow, competition for water resources is expected to increase (World Bank, 2022). Freshwater is particularly constrained in proportion to its required uses (Stenzel et al., 2019), which demands that stakeholders exercise control of how it is used. There is plenty of evidence to show that freshwater biodiversity is already suffering acutely from over-abstraction of water, pollution of rivers, lakes and groundwater as well as poorly planned water infrastructure (WWF, 2009).

Despite the eminent danger of water shortage that countries such as South Africa are facing, water scarcity is still considered an external risk factor in construction projects (Khan & Gul, 2017). However, several researchers have concluded that water scarcity will most certainly cause delays in future construction projects (Assaf & AlHejji, 2006; Muhwezi et al., 2014). When the construction industry is negatively affected due to water scarcity, then the real estate industry is also be affected. Such a situation will contribute to project delays and poor-quality buildings.The costs to property investors may also rise when there are delays resulting in cost overruns and consequent reductions in quality (Olawale & Sun, 2010).

According to Ramantswana, Mdingi, Maake & Vuyani (2021), the cost, time and quality are the most common variables against which the success or failure of a project is determined. A project is usually deemed successful when it is delivered at the required quality within the agreed budget and timeframe (Larsen, J.K., Shen, G.Q., Lindhard, S.M. & Brunoe, T.D. 2016). Failure to achieve these targets may be due to many aspects associated with internal and/or external factors (Khan & Gul, 2017). Water scarcity or drought falls within the external factors or risks over which the client and contractor have little control.

Similarly, water shortages translate into higher energy prices, higher insurance and credit costs, and lower investor confidence, all of which further undermine business profitability (Orr & Cartwright, 2010). More common than the risk of insufficient water is that of businesses finding their comparative or competitive advantage undermined by cost inflation driven by water scarcity. WWF (2009) argue that as water becomes scarce, water tariffs and other pricing mechanisms tend to increase, due to greater competition for water between sectors, higher water search costs, the need to drill deeper boreholes, higher pumping costs and recouping the cost of expensive water transport schemes. Understanding water scarcity is important for formulating policies on both a local and national scale.

Furthermore, Liu et al. (2017) argues that water scarcity has become a major constraint to socio-economic development and a threat to livelihood in increasing parts of the world. Since the late 1980s, water scarcity research has attracted much political and public attention (Liu, et al., 2017). WWF (2009) pointed out that as the global population increases, so will the need for: (i) doubling the water for irrigation to feed these ‘extra mouths’, (ii) building more dams to generate new hydropower as economies develop and competition from the water demands of bio-energy crops intensify and (iii) pollution of water resources will continue. Liu et al. (2017) added that population growth, economic development and dietary shift (towards more animal products) have resulted in an ever increasing demand for water and, consequently, pressures on water resources.

Studies shows that the water problem is a governance crisis. The United Nations (2003) indicated that water scarcity occurs when the aggregate impact of all users impinges upon the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully. Rogers (2003) also pointed out that water scarcity is a “governance crisis and must not be looked at as a resource crisis:. Indeed, at a global scale there is probably enough water to provide for the present and future generation. But due to poor governance on the global scale, water management is not given priority, and this failure of governance is leading to depletion of freshwater resources (WWF, 2009).

To show that water scarcity is indeed a governance crisis, Falkenmark et al. (2007), identified four drivers that contribute to physical water scarcity.

i. Demand-driven water scarcity – this factor occurs when water demand is higher than the capacity of available water sources.
ii. Population-driven water scarcity – this factor occurs when demand is population-driven. High population levels place pressure on the amount of water physically available, leading to per capita water shortages. According to UNICEF (2021), "physical water scarcity is exacerbated by rapidly growing urban areas which place heavy pressure on adjacent water resources".
iii. Areas more susceptible to severe physical water scarcity – these areas are usually located where high population densities converge with low availability of freshwater (FAO, 2007), Gauteng and Western Cape provinces being typical examples (Mnisi, 2020).
iv. Climate-driven water scarcity – this factor occurs when insufficient precipitation and high evaporation create low available stream run-off, that leads to limited water availability. Climate-driven water scarcity is exacerbated by global climate change, climate variability and recurrent droughts. Mnisi (2020) stated that South Africa is recognised as a water-scarce country with an annual precipitation of 450 mm. This figure is well below the world average of 860 mm per year (Botai, Botai, de Wit, Ncongwane & Adeola (2017).
v. Pollution-driven water scarcity – this factor occurs when water quality is degraded to the point that it is unusable. In this case the water may be available but remain unsuitable for beneficial uses resulting in water scarcity (Mnisi, 2020). In South Africa the scarcity of freshwater is exacerbated by the major increase in pollutant fluxes into river systems arising from river catchments (Rand Water, 2017). These fluxes are caused by urbanisation, deforestation, destruction of wetlands, industry, mining, agriculture, energy use and accidental water pollution (Mnisi, 2020).

The rational for this research study arose from the fact that in 2015 Cape Town started to experience drought conditions and water reservoirs reached even more critically low levels in 2017/18 (SIWI, 2020). The drought was driven by physical factors such as a lack of winter rainfall and increasing temperatures attributable to the effects of climate change. According to Organisation for Economic Cooperation and Development, it was exacerbated by anthropic factors such as rising urban population and competition among local water users, all placing enormous stress on the limited water resources (OECD, 2018). The 16 April 2018 was supposed to be the day that Cape Town switched off its taps, known as Day Zero, defined as the point at which the dam levels fell to 13.5%, therefore, requiring taps in the city of Cape

Town to be shut off and severe water rationing to be implemented, requiring citizens to fetch a daily 25 litres per person allocation at public points of distribution (SIWI, 2020). Although Day Zero did not occur, the Cape Town water crisis exposed serious vulnerability to water scarcity issues for the city, the surrounding urban agglomerations and the South Africa at large. Thus, this study contributes to knowledge that can be applied towards ensuring future water conservation.

2.3 Guidelines for Freshwater Use

It was stated that; "If we wish to build a sustainable future, the effective and wise use of water is essential" (Guideline to Water Use, 2013). The National Water ACT (NWA) was drafted in 1993, its purpose was to provide a legal framework for the effective and sustainable management of water resources in South Africa (Government Gazette, 2013). The Act recognises that in as much as water is a natural resource and that it belongs to all people, past discriminatory laws and practices hindered equal access and use of water. Accordingly, the overall responsibility and authority over the national water resources lies with the government and, more specifically, the Department of Water and Sanitation (DWS) as the Custodian of the nation's water resources (Government Gazette, 2013). The mandate for this body is: to manage the use of water; protect water quality; allocate water and promote the integrated management of water resources with the participation of all stakeholders. Overseeing this task is the Ministry of Water and Sanitation that acts as the public trustee for water resource management on behalf of the government. The Minister of Water and Sanitation assumes the responsibility for all aspects of water management, including being responsible for establishing how much water is used, by whom and where, in order to measure how much water is actually available for use (Government Gazette, 2013).

One of the NWA's (1993) main concerns is industrial wastewater management. It prescribes precautionary measures that water users must follow in as far as construction, maintenance and operational practices are concerned. However, there appears to be no guidelines regarding industrial freshwater use.

2.4 Sources of Water in Housing Construction

The construction industry consumes a considerable amount of water at every stage of a project's lifecycle during the construction phase. Water is necessary for the mixing of cement concrete, preparation of mortar and curing of work. However, there is lack of literature regarding the sources of water used and water saving practices implemented in housing construction. For instance, while Musir et al. (2022 p.3) argue that "there is a gap of knowledge and awareness on sustainable construction and its practices", Moghayedi et al. (2023 p. 2) show that in South Africa "the provision of low-cost housing struggles with inefficient water usage".

Some researchers have investigated the use of wastewater in the making or curing of concrete. Eriksson et al. (2002) wrote about the use of grey wastewater, e.g., wastewater from kitchen, bathroom or laundry, suggesting that this kind of wastewater could be used in making concrete without any dangerous effects. Other scholars have argued that the use of wastewater in mixing and curing of concrete structures may reduce the environmental effects due to this effective disposal of wastewater and will also minimize the cost of construction (Jabri et al.; 2011).

The durability of the concrete is another issue that is raised. Durability refers to the ability of the concrete to withstand chemical attacks, weathering conditions and the abrasion consistency when exposed to environmental conditions. Su, Miao & Liu, (2002) states that although concrete is considered durable when exposed to environmental conditions, it suffers from deterioration in waste treatment plant structures. Varshney et al. (2021) added that the type of wastewater and its components are dependent upon the source of wastewater, stating that each type of wastewater causes different effects on the properties of concrete.

Water consumption during housing construction is simply unavoidable. However, water resource management in building construction and operation is still lacking, especially because the amount of water used per unit area of construction largely remains undocumented (Bardhan, 2011). This study places great importance on understanding the methods of water management during housing construction and sheds light on the amount of water that is used per unit area of construction.

It is evident that as the demand for housing construction increases, water use in the construction of housing projects also increases. Given that the world is faced with water constraint, there is a need to raise awareness of the issue of water conservation during the construction phase (Botai et al. 2017), and for that reason, this research aims to investigate water conservation during the construction of housing projects in Cape Town, South Africa.

In support of the above argument, a study by dos Santos & da Silva (2015) on water consumption in construction projects in the city of Recife, capital of the state of Pernambuco, Brazil, showed that the workers consume more than 50.0% of the water used while only 16,91% is used directly in the construction. It further showed that 25,19% is used in indirect activities, while less than 3.0% in utilized during the stages of coating and masonry and 15.0% during the stages of structure and waterproofing (dos Santos & da Silva, 2015). In another survey conducted in Pune, the traditional/conventional method of construction is used for most residential projects and 0.5% for commercial, however, water consumption is high and water is wasted, especially during curing (Patil, 2016). Hence it is deemed important for this study to understand the water requirement in various construction activities, such as preparation, casting and curing, as well as how to ensure the optimum use of water during construction, thus, reducing wastage.

The industry of civil construction contributes significantly to the exhaustion of the natural resources, especially water, and has the power to influence the use of this resource through the implementation of conservation measures. Despite the studies undertaken regarding the rational use of water in buildings, little has been explored on the construction stage. Due to this lack of information, this study aims to investigate water consumption on construction sites in the city of Cape Town. The study focuses on housing construction in Cape Town and, therefore, people working in housing construction companies in Cape Town were considered to be primary sources for the information regarding water use and methods of efficiency water use in housing construction and, therefore, targeted as participants for the study. A Delphi method was used for this research ensure reliability of information by consulting with experts in the construction industry (Sourani & Sohail, 2014).

Studies that have focused on water efficiency during the construction stage of a building have investigated various methods of efficient water use during the operational stage of a building (Carragher, Stewart & Beal., 2012). Waidyasekara and Lalith De Silva, (2016) highlighted the cost of water and sources of water as main drivers that promote efficient water use on construction sites. The study also identified that the lack of priority for water management was the main barrier among a host of other managerial functions.

Furthermore, a study conducted in the Western Cape, Gauteng, Mpumalanga and Limpopo provinces of South Africa, on the effects of water scarcity in the construction industry, found that although construction projects require considerable quantities of water, the volume of water usage varies depending on the type and magnitude of the construction project (Ramantswana et al., 2021).

Largely, however, water use during construction phase has been given a low priority (Waylen et al., 2011), and there is an urgent need for water scarcity issues to be addressed. Sustainable development in housing cannot be achieved without the essential elements of environmental protection together with economic, social and cultural preservation for future generations.

2.5 Water Conservation and Efficient Use of Water

The shortage of water is arguably one of the most important challenges facing the world today. Due to the growing shortage of freshwater, the future demand for water is one of the key issues that must be addressed.

Water conservation refers to the effort to reduce water consumption. The Department of Water and Sanitation (2000), defines water conservation as being the efficient use and saving of water, achieved through measures such as water saving devices, water-efficient processes, water conservation and demand management and water rationing. The Water Conservation and Demand Management National Strategy Framework (DWAF, 1999a) interprets water conservation as being the minimisation of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water.

It has been argued that the demand placed on water resources has reached unsustainable levels due to declining and increasingly variable rainfall patterns, population growth, urbanisation and increasing per capita water consumption (Davison 2008; Dingle 2008; Pigram 2007). The 2018 edition of the United Nations World Water Development Report stated that nearly 6 billion peoples will suffer from clean water scarcity by 2050 (Boretti & Rosa, 2019).

The challenge of climate change and how it has impacted attitudes and behaviour towards water conservation has been raised. Randolph and Troy (2008) argued that climate change and ecological crises have had little effect on the actual consumption behaviour of individuals, households and communities. In contrast, Clark and Brown (2006) study conducted in Bulgaria found that the more aware and informed people were about climate change, the more likely they were to implement conservation measures in their home and, therefore, they concluded that awareness of climate change and global warming was a significant factor in a person's intention to conserve water. Indeed, Roseth's (2006) study of community views on water shortage and drought identified that climate change was the second-largest factor that participants felt contributed to water shortages. This finding suggests that, despite Randolph and Troy's (2006) assertions, communities are connecting issues of climate change with their water behaviours (Gilbertson, Hurlimann & Dolnicar, 2011).

In addition, water efficiency means promoting the sustainable use of water, while using solutions that enable comprehensive reductions in the waste of domestic water (Department of Water & Sanitation, 2022). Water efficiency aims to make the use of water sustainable to a broader extent. The purpose is to both reduce unnecessary water consumption and make water consumption more sustainable by focusing on responsible solutions for the supply and use of water (Department of Water & Sanitation, 2022).

According to Waylen et al. (2011), reducing water use on construction sites is possible if the challenges of “value for money, the work environment and habit of workers can be overcome”. Waidyasekara and Lalith De Silva (2016) argued that there is a need for behavioural change among construction workers in order to enhance efficient water use on construction sites.

Water pricing has been used as a strategy to control water use in the belief that the right price can encourage efficient water use (Johnson, Chairman ANC, 2014; Paula et al.; 2018). A study conducted in Australia to explore the awareness of water use, in which it was argued that if water users are unaware of the amount of water they are using, pricing controls may be meaningless. The study findings indicate that one in five (19%) of all participants said they knew how much water they used in a quarter (Randolph & Troy, 2008). Willis et al., (2011b), stated that pricing of water was initially predicted to influence consumption but this belief has been dispelled on the basis that residential water demand is largely price ‘inelastic’ compared to other life essentials. Barrett (2004) revealed that only very large external water users are likely to be sensitive to price changes.

Much of the effort made to enhance water efficiency and lower its demand in buildings has focused on the water directly consumed by occupants, including the usage of efficient appliances. While such measures have greatly reduced water usage, direct water consumption within buildings represents only a small portion of the entire water demand (El-Hameed, Mansour & Faggal, 2017).

In the construction industry, there are many soft measures related to policy, planning and workers’ behavioural change that could be used to improve water use efficiency on sites (Waidyasekara & Lalith De Silva, 2016) such as good housekeeping, monitoring and targeting of water use and resorting to the use of available abstracted water. Waidyasekara and Lalith De Silva (2016) considered monitoring and targeting water use as the first step in implementing a water use efficiency programme on a construction site.

Several scholars (Azhar et al., 2011; Bourg, 2010, Bribián et al., 2011; Horne 2012; Joyce 2012; Juan et al., 2010; McComack et al., 2007; McNab et al., 2011; Savenije & Van der Zaag 2002; Tam & Lee, 2007; Utraja 2010; Waylen et al., 2011; Zhang et al., 2011) have identified policies and planning recommended for implementation of water use efficiency programmes on construction sites. These policies include:

- developing a builder’s guidebook for reference,

- implementing environmental policies on natural resources,
- implementing a licensed water abstraction system (surface water/tube well),
- increasing the unit rate for water,
- integrating water efficient techniques during the pre-design and tender stage,
- introducing a water action plan at the inception,
- implementing rainwater collection and reuse,
- introducing sub-metering systems,
- implementing water auditing and
- introducing water leak detection and monitoring systems.

Further, several other scholars have supported the need for attitude and behavioural change on construction sites (Liu & Ping 2012; McNab et al., 2011; Shen et al., 2007; Tam & Lee 2007; Waylen et al., 2011). They identified the following methods to alter the alttitude and behaviour of site workers such as the need to:

- increase water awareness among workers,
- improve monitoring and supervision,
- assign responsibility and targets among the site staff and
- introduce penalties for unsustainable practices by site staff.

Other scholars (Bourg, 2010; Juan et al., 2010; Tam & Lee, 2007; Utraja, 2010; Waylen et al., 2011; Zhang et al., 2011) have supported the need for alternative construction methods including the need to:

- introduce curing agents,
- implement closed loop systems,
- introduce dry wall partitions instead of brick and block walls,
- use admixtures/chemical additives,
- use precast or prefabricated construction methods,
- use pre-mixed concrete and pre-mixed mortar and
- use steel intensive construction methods.

Lastly, Azhar et al., 2011; Bourg, 2010; Juan et al., 2010; Liu & Ping, 2012; Lockwood, 2006; McNab et al.,2011; Waylen et al., 2011) and have argued in favour of the use of efficient technologies in housing construction including the use of:

- dust suppression vehicles with sprinklers,
- efficient showers (low-flow showerheads),
- fan misting systems for dust suppression,

- high pressure trigger operated spray gun hoses,
- low flush cisterns/urinals/waterless urinals,
- pressure reducing valves,
- sprinkler systems for curing concrete,
- vacuum toilets and
- washing bays for wheel washing.

Many studies focusing on the water use in construction during operation only may fail to accurately identify the most optimum solutions for effectively improving the water efficiency of any building, by solely highlighting the significant impact of water efficiency during building construction (Ahmed Abd El-Hameed, Yasser Mansour & Ahmed Faggal, 2017).

Water conservation is essential to sustainable development and among human activities, buildings are responsible for a significant portion of total water consumption. Pigram (2007) stated that there is a substantial need for water conservation to ensure more sustainable water management with minimal impact on economic growth or individuals' quality of life.

South Africa is a water-scarce country (Department of Water Affairs and Sanitation, 2000). The average annual rainfall is 500mm compared with the global average of 800mm and is unevenly distributed both geographically and seasonally. Rainfall is also highly variable over time, resulting in unpredictable and often lengthy droughts (McKenzie et al., 1999). The high evaporation rates that prevail mean that much of the rain that falls is soon returned to the atmosphere before it can be effectively utilised. South Africa is also poorly endowed with groundwater (Department of Water Affairs and Forestry, 2000). Following the recommendations made at the National Water Indaba held in Cape Town during November 2009, the Sustainable Water Management Plan (SWMP, 2017-2022) for the Western Cape Province was developed. Its goal was to create a plan that is critically aligned with national, provincial and local policy to enable effective collaboration across government departments and all stakeholders who have a shared responsibility for achieving sustainable water management in the Western Cape (Western Cape Government, 2018). In addition, according to Department of Water Affairs and Forestry report (2000), "South Africa is a relatively dry country, with irregular rainfall across the country and from year to year". This situation calls for all stakeholders to adopt water conservation strategies, including efficient water use in the construction industry, agriculture and households, among others.

The Western Cape is supplied by two water management areas. OECD (2021) studies indicated that the Breede-Gouritz catchment supplies 59% of the Cape Town supply while the Berg-Olifants WMA supplies 41% (Western Cape Government, 2018, p.13) in the surrounding areas. Cape Town relies heavily on surface water. Indeed, Cape Town receives 95% of its water from a system of 6 rain-fed dams that also supply agriculture and other urban areas (Western Cape Government, 2018). The city of Cape Town provides water and sanitation services to more than 4.2 million people via water and sewer connections that supply nearly 600 000 domestic properties (City of Cape Town, 2018, p.14) and basic services comprising public water points and shared toilet facilities to about 230 000 households living in informal settlements (OECD, 2021).

The Water Conservation and Water Demand Management Strategy is a fundamental step in promoting water use efficiency and is consistent with the National Water Act (Act 36 of 1998) which emphasizes effective management of South Africa’s water resources (Buyelwa, 2004). The urgency to adopt principles of sustainability in water usage must start with policies to regulate day-to-day activities (Walton et al., 2005). According to The Nature Conservancy 2018 report, current forecasts suggest that an additional 300-350 million litres (0.3-0.35 million m3) of water a day will be needed by 2028 to ensure supply meets demand (The Nature Conservancy, 2018).

2.6 Barriers to Water Conservation

Many studies have connected people's behaviours with their beliefs, perceptions and attitudes (Ajzen, 2005). Recent research suggests that attitudes and perceptions also influence water use behaviours (Clarke & Brown, 2006). For example, attitudes about water pricing and allocation of water for recreation are known to influence water conservation (Syme, Nancarrow & Seligman, 2000). Even when conservation programmes’ benefits far exceed their costs, negative attitudes towards them can be a major barrier (Ward, Michelsen & De Mouche, 2007). For example, a study of water conservation in Mexico found that perceived water waste by neighbours decreased the likelihood of residents conserving water (Corral-Verdugo, Frias-Armenta, Perez-Urias, Orduna-Cabrera & Espinoza-Gallego, 2002). Conversely, belief that the water utility and other members of the community are actively reducing their water use increases the likelihood of conserving water (Jorgensen, Graymore & O'Toole, 2009). Similarly, beliefs such as household water use will not make an appreciable impact on water resources and water conservation methods are not reliable or effective, together with a lack of knowledge of water usage, are major factors influencing household water conservation (Teodoro, 2009). Trust in government has also been suggested as a possible driver of water conservation and has been offered as a topic for future research (Jorgensen, Graymore & O'Toole, 2009).

Hurlimann (2008), conducted a study on the barriers to implementing water efficiency practices in the built environment and found that policy was necessary for the incorporation of water efficient initiatives. Furthermore, Hurlimann (2008) identified that the cost of implementing water efficient initiatives was the main barrier. Other barriers include legislation and institutional impediments and knowledge gaps (Hurlimann, 2008).

Addo et al. (2018) argued that behaviours that may influence water conservation are constrained by barriers. Most identified barriers are related to personal capabilities such as lack of knowledge and education about the need for water conservation and/or inadequate conservation information.

The report by Waylen et al. (2011), titled *An action plan for reducing water usage on construction sites*, highlights the issues regarding usage of sustainable water during construction and targets to rectify these problems. Waylen et al. (2011) identified three major barriers for introducing water use efficiency during construction, that includes value for money, the work environment and workers' habits. Policy is important not only for housing construction but also to ensure that sustainability is a central part of housing projects (Ibid).

Barriers to water-conservation behaviour prevent people from acting pro-environmentally regardless of their attitudes or intentions (Kollmuss & Agyeman, 2002). As mentioned above water-conservation activities are more likely to occur when individuals believe that water is scarce and when they perceive that other consumers are likewise conserving water (Corral-Verdugo et al., 2002). Barriers and drivers of water-conservation behaviour are influenced by many issues, including psychological factors such as values, beliefs, trust, affective (emotional) reactions and attitudes (Smith, Brouwer, Jeffrey & Frijns, 2018), socioeconomic factors such as income, water pricing and policies, environmental factors such as seasonal variation and demographic factors such as age.

Fielding et al. (2012) stated that concerns about the installation and functionality of water-efficient devices and the inconvenience resulting from practicing water-saving behaviour are major problems for everyday water-conservation activities. Addo et al., 2018) conclude that water-conservation behaviour can be improved if such practices are profiled to identify barriers to and drivers of water-conservation activities.

Heberlein 2012) identified attitude as one of the above barriers and argued that attitudes toward water conservation behaviours are likely to depend on the exact behaviour towards which the attitude is directed. Conservation behaviours that require higher degrees of lifestyle change may be challenging for most people to adopt and, therefore, individuals may express less positive attitudes toward such behaviour (Heberlein 2012).

An Australian study on people's attitudes to water conservation and their reported practices suggested that Australians generally had very positive attitudes to water conservation and water-saving equipment (Dolnicar & Hurlimann, 2010, pp. 43–53). An analysis of U.S., Australian and UK studies found that retrofitting projects installing efficient appliances resulted in water consumption reductions of between 9 and 12% (Singha & Aljamal, 2020).

Another Australian study found that water conservation is important among 94–98% of participants (Singha & Aljamal, 2020). This difference could be due to the increased awareness that Australians have water scarcity issues in many areas. Furthermore, Singha and Aljamal (2020) refer to various UK studies in UK, that found a strong connection between water scarcity encounters with water awareness and water conservation action. A study by Head and Muir, (2007, pp. 889–905) shows that 69% of people who perceived that there was a low water scarcity chance also identify as not being water conscious. In relation to the theory of planned behaviour (Ajzen, 1991, pp. 179–211), the most immediate predictor of behaviour are intentions that represent a motivation or desire to engage in an action. In addition, intentions are influenced by attitudes, subjective norms and perceived behavioural regulation (Singha & Aljamal, 2020). Furthermore, personal moral beliefs about the environment are expressed as feelings of responsibility to use natural resources in a restricted manner and these feelings may have a positive impact on pro-environmental behaviour (Singha & Aljamal, 2020).

2.7. Conclusion

It becomes apparent from the above thorough examination of existing literature that the topics of water use and conservation in housing construction have not received adequate attention in recent scholarly discourse. While some literature exists on these subjects, much of it is outdated and fails to address the current challenges and advancements in the field. Consequently, there is a clear gap in the literature that necessitates further research and the generation of updated information to address contemporary issues and developments in water conservation practices within the context of housing construction.

Moreover, the review of literature underscores the critical importance of addressing water use and conservation within housing construction, especially in regions facing water scarcity challenges such as Cape Town and other areas of South Africa. The limited availability of recent literature highlights the urgency of conducting fresh research to fill this gap and provide current insights into effective water conservation strategies and their implementation in construction activities. By conducting new research, scholars and practitioners can contribute to the advancement of knowledge in this area and provide practical solutions to mitigate the negative impact of construction activities on water resources.

Furthermore, the review of outdated literature emphasizes the need for researchers to explore emerging trends, technologies and best practices in water conservation within housing construction. By conducting updated research, the study can build upon existing knowledge and address the evolving needs and challenges of the construction industry in adopting sustainable water management practices. This renewed focus on current literature can inform policy development, industry practices and academic discourse, ultimately leading to more effective and sustainable approaches to water conservation in housing construction.

The review of literature highlights the imperative for conducting fresh research to fill the existing gap in knowledge and provide updated insights into water use and its conservation in housing construction. According to the existing literature there is water wastage in the building processes and not many studies have investigated this subject intensively. By addressing this gap, the researcher intends to contribute to the advancement of theoretical understanding and practical applications in the field, ultimately fostering more sustainable and environmentally responsible construction practices.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Methodology

This chapter outlines the research methodology employed in collecting and analyse data. It includes the research design, the methods and tools of data collection, reliability and validity of the methods of study, and the limitations encountered. Additionally, the chapter is set up in alignment with the research aim and the rationale for data collection.

3.2 Research Design

Research design plays a pivotal role in structuring data collection and analysis. Quantitative, qualitative and mixed-methods approaches offer distinct strategies for investigating research questions. The methodology encompasses data collection methods, research design and data analysis techniques. The study followed a quantitative approach for data collection with a mix of qualitative data. The study used a self-designed questionnaire to collect both quantitative and qualitative data, which included closed-ended questions and open-ended questions respectively. While quantitative research aimed at numerical analysis to establish relationships between variables, qualitative research explored the aspects difficult to quantify mathematically (Almeida, Faria & Queirós, 2017). And therefore, by using this mixed-methods, the research aimed to offer a comprehensive understanding of the research problem.

3.2.1 Quantitative Research

Quantitative research, as opposed to qualitative research, focuses on numerical data and employs statistical analysis to explore cause-and-effect relationships between variables (Hennink, Hutter & Bailey, 2011). This approach emphasizes objectivity and generalizability, making it suitable for testing hypotheses and drawing conclusions based on empirical evidence (Leedy & Ormrod, 2010). In the context of the study on water conservation practices in housing construction, quantitative research offers a structured framework for systematically examining the relationships between variables such as construction methods, water usage, and environmental impact.

By adopting a deductive approach, this study aims to validate hypotheses derived from existing theories or empirical observations (Leedy & Ormrod, 2010). This approach involves formulating specific hypotheses based on theoretical frameworks or prior research, then collecting data to test the validity of these hypotheses (Hennink et al., 2011). In the case of water conservation practices, hypotheses may include predictions about the effectiveness of specific construction techniques or the relationship between water usage and project cost.

Quantitative research methods allow for precise measurement and quantification of variables, enabling researchers to analyse data objectively and draw statistically sound conclusions (Nieuwenhuis, 2007). By employing standardized instruments such as surveys or experiments, researchers can collect consistent, comparable data across different contexts, enhancing the reliability and validity of their findings (Leedy & Ormrod, 2010).

Overall, quantitative research provides a rigorous framework for investigating complex phenomena such as water conservation practices in housing construction. By systematically testing hypotheses and analysing numerical data, researchers can gain valuable insights into the factors influencing water usage and identify strategies for promoting sustainable construction practices.

3.2.2 Qualitative Research

Qualitative research, in contrast to quantitative approaches, delves into the nuances and complexities of real-world phenomena, prioritizing depth of understanding over breadth of information (Leedy & Ormrod, 2010). This methodological approach is well-suited for investigating the multifaceted nature of water conservation practices during housing construction, as it allows researchers to explore the contextual factors and social dynamics that shape these practices.

One of the key strengths of qualitative research lies in its ability to capture the rich, nuanced experiences and perspectives of individuals within their natural environments (Leedy & Ormrod, 2010). Methods such as case studies, ethnographies and content analysis offer researchers a range of tools for exploring these complex processes. For instance, a case study approach may involve in-depth examinations of specific construction projects to uncover the underlying factors influencing water usage decisions and conservation efforts.

Ethnographic research, on the other hand, involves immersive, prolonged engagement with construction professionals and stakeholders to gain insights into their behaviours, attitudes, and cultural norms related to water conservation (Leedy & Ormrod, 2010). By embedding themselves within construction sites or project teams, researchers can observe firsthand how water management practices are enacted and negotiated in real time.

Content analysis provides yet another avenue for qualitative inquiry, allowing researchers to systematically analyse documents, reports and other textual materials related to water conservation in construction (Leedy & Ormrod, 2010). This method enables researchers to uncover patterns, themes and discourses surrounding water usage and conservation within the industry.

Overall, qualitative research offers a holistic understanding of water conservation practices during housing construction by illuminating the social, cultural and organizational dynamics that shape these behaviours. By employing diverse methodologies and engaging directly with stakeholders, researchers can uncover valuable insights that may not be captured through quantitative approaches alone.

3.2.3 Mixed-Methods Research

Mixed-methods research represents a comprehensive approach that combines qualitative and quantitative methodologies to provide a more holistic understanding of the research problem (Denscombe, 2007). By integrating multiple methods within or across paradigms, researchers can triangulate findings, validate results and gain diverse perspectives on the phenomenon under investigation (Hennink et al., 2011).

The integration of qualitative and quantitative approaches in mixed-methods research offers several advantages. Firstly, it allows researchers to capitalize on the respective strengths of each method. Qualitative methods, such as interviews and observations, enable researchers to explore complex phenomena in depth, uncovering underlying meanings and contextual factors that may not be captured through quantitative measures alone (Leedy & Ormrod, 2010). On the other hand, quantitative methods provide systematic, numerical data that allow for statistical analysis, hypothesis testing, and generalizability of findings (Denscombe, 2007).

Moreover, mixed-methods research emphasizes the importance of triangulation, which involves comparing and contrasting findings from different sources or methods to validate results and enhance the credibility of the study (Hennink et al., 2011). By examining the research problem from multiple angles, researchers can develop a more comprehensive understanding of the phenomenon, mitigating the limitations of any single method (Denscombe, 2007).

The selection of mixed-methods techniques should be guided by the research topic, question(s), aims and the competencies of the researcher (Hennink et al., 2011). Additionally, the successful integration of qualitative and quantitative methods requires a significant investment of time, skills and resources, highlighting the importance of careful planning and execution (Leedy & Ormrod, 2010).

Overall mixed-methods research offers a flexible and rigorous approach to inquiry, allowing researchers to address complex research questions and generate rich, nuanced insights into the phenomena under investigation (Denscombe, 2007). By combining qualitative and quantitative methodologies, researchers can leverage the strengths of each approach to produce more robust and comprehensive findings.

3.3 Research Approach

The chosen research methodology aligns with the study's objectives and aims to address the research problem effectively. Quantitative research offers a systematic approach to analyse numerical data, validate hypotheses and assess relationships between variables. By employing this approach, the researcher aims to fill the gap in understanding water use and conservation practices during housing construction in Cape Town.

Data Research sources adopted in the study:

i. Primary Data – Literature review
ii. Secondary data – Structured Questionnaire with open-ended questions.

3.4 Chosen Research Methodology for the Study

The research involved the use of quantitative and qualitative methods to systematically analyse the collected data and transform it into meaningful information. This study utilized a structured questionnaire of closed-ended and open-ended questions to collect both quantitative and qualitative data from the respondents. The questionnaire comprised Likert scale questions ensuring comprehensive data collection (Rene & Adonisi, 2009).

3.5 Data Collection Techniques

Data collection involved the use of a self-designed questionnaire with both closed-ended and open-ended questions. The questionnaire designed by the researcher was designed using google link forms which was sent to respondents via email and via WhatsApp platforms where they could directly complete the questionnaire. The researcher experienced some challenges to get back the responses from respondents and had to follow up with phone calls to respondents. Eventually had to print the questionnaires and physically take it to the responds who did not respond to the online approach of using the google form link and wait for them to complete the questionnaire. The questionnaire was distributed to a sample of 204 respondents. The sample included construction professionals at government departments, particularly the Department of Human Settlements and operational professionals of three different constructions companies. The professionals included Project Managers, engineers, Architects, Quantity Surveyors, Health and Safety consultants. This ensured a representative sample.

The researcher identified qualitative research approach as the major technique to conduct this research because of its advantage to reach a large number of respondents. Based on the literature review there are exiting studies investigating water usage during building construction processes therefore the study aimed to test theory and build it from ground up.

3.6 Reliability and Validity

Ensuring the reliability and validity of research instruments is paramount to producing accurate and credible results. In this study, rigorous measures were taken to enhance the validity and reliability of the questionnaire used for data collection.

Validity, a concept that refers to the accuracy and trustworthiness of research findings, was addressed through various techniques. Expert consultation and pilot testing were conducted to validate the questionnaire and ensure that it effectively measured the intended constructs (Maxwell, 1996). Additionally, the questionnaire was designed to reflect the desired measurements, enhancing its construct validity according to the criteria set by Leedy and Ormrod (2010). Techniques such as triangulation, respondent validation and grounded data were employed to further improve the validity of the study (Denscombe, 2007). By incorporating these measures, the study aimed to minimize bias and ensure that the findings accurately reflected the research objectives.

Reliability, on the other hand, pertains to the consistency and dependability of the measurement instrument (Leedy & Ormrod, 2010). To assess reliability, Cronbach's alpha coefficient analysis was conducted using statistical software such as SPSS. This analysis examined the correlation of item scores for questions expected to yield consistent responses (Kumar, 2010). A Cronbach's alpha coefficient closer to 1 indicates higher reliability, with values above 0.7 generally considered ideal (Kumar, 2010). By conducting reliability analysis, the study sought to reduce measurement error and ensure that the data collected were reliable and consistent across participants.

By addressing validity and reliability concerns through expert consultation, pilot testing and statistical analysis, the study aimed to produce robust findings that could withstand scrutiny and contribute to the existing body of knowledge on water conservation practices during housing construction. These efforts underscored the commitment to conducting rigorous research and generating meaningful insights into the research problem at hand.

3.7 Limitations

Despite the meticulous methodology employed, this study encountered some limitations which warrant acknowledgment to contextualize the findings and interpretations.

Firstly, the study relied solely on the questionnaire as a tool for data collection. While the survey questionnaire offered valuable insights, incorporating interview and observation methods could have enriched the study by providing deeper contextual understanding and enabling triangulation of data sources (Maxwell, 2013). Follow-up interviews, for instance, could have offered additional perspectives and validated the questionnaire findings, enhancing the study's generalizability.

Secondly, obtaining permissions from construction companies posed challenges. This hindered the collection of comprehensive data and may have introduced selection bias, impacting the sample’s representativeness. Despite efforts to engage with key individuals, logistical constraints and bureaucratic processes limited access to crucial information.

Thirdly, the geographical scope of the study was restricted to the Western Cape province of South Africa. While this focus allowed for in-depth exploration within a specific context, it also limited the generalizability of the findings to other regions or settings. A more extensive geographic coverage could have provided broader insights into water conservation practices in housing construction.

Moreover, the study faced challenges in targeting specific occupational categories for data collection. While efforts were made to include diverse perspectives, certain occupational groups, such as operational staff, were not adequately represented. This limitation may have overlooked valuable insights from these stakeholders and, thus, skewed the findings of this study.

Lastly, the study's design necessitated a focus on positions in technical, management and technology areas, as recommended by Kuratko et al. (2014). However, this approach may have overlooked valuable contributions from other occupational categories within the construction industry. Achieving inclusivity while maintaining relevance to the research objectives proved challenging, highlighting the need for careful consideration of participant selection criteria in future studies.

By acknowledging these limitations, the study aims to provide transparency and context to its findings. While these constraints may have impacted the scope and generalizability of the research, they also underscore opportunities for future inquiry and methodological refinement in the field of water conservation practices during housing construction.

3.8 Chapter Summary

This chapter explained the methodological approach employed to investigate water use and conservation practices during housing construction in Cape Town. It details the approaches and methods used to collecting and analysing and interpretating data to address the research objectives. Despite limitations, the chosen methodology facilitated comprehensive data collection and analysis, laying the groundwork for the subsequent chapters' findings and discussions.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

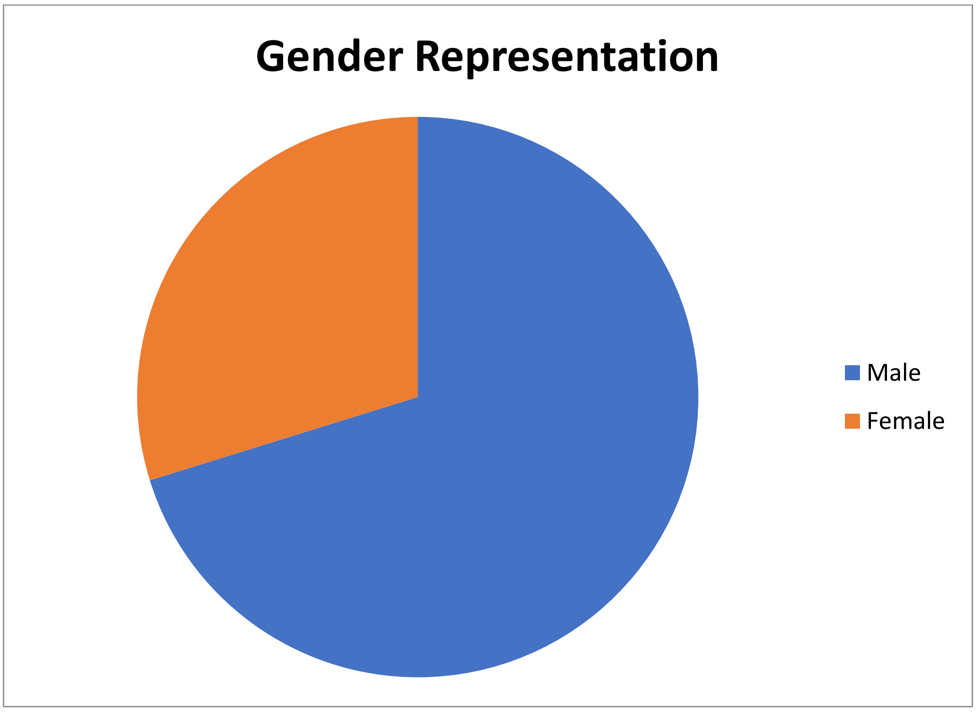
4.0 Introduction

To comprehend the dynamics of water conservation within the realm of housing construction in Cape Town, South Africa, an in-depth analysis was conducted on the collected data. This chapter is a presentation of the findings derived from the various demographic aspects of the participants and their roles and experiences in the construction industry.

4.1 Profile of Participants

4.1.1 Gender representation

Graph 4.1: Gender representation



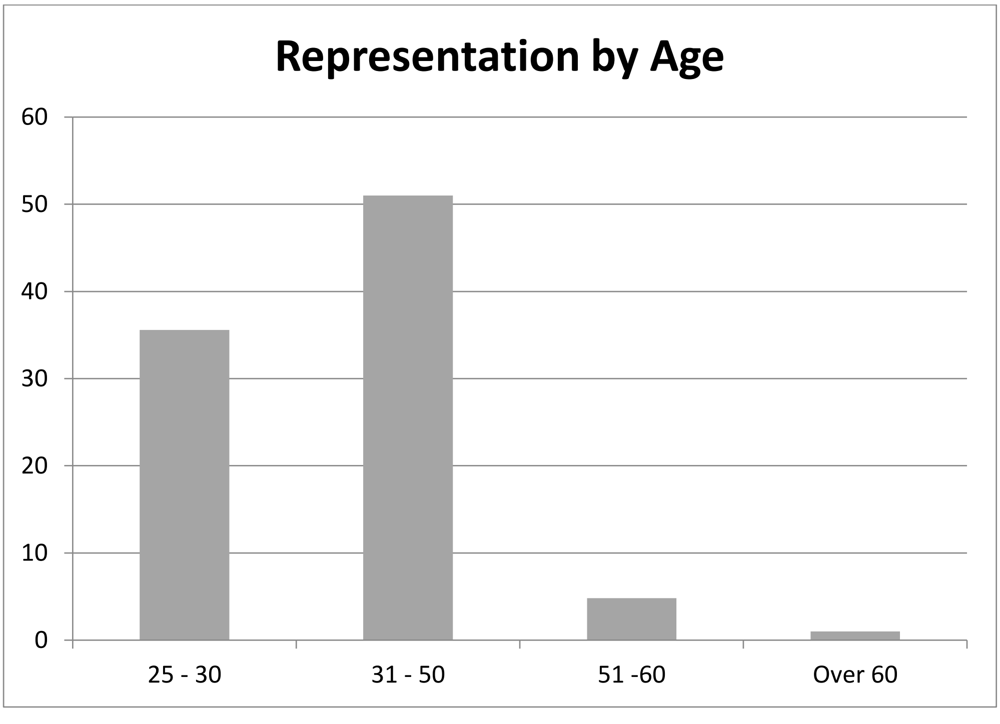
Source: Azola, 2024

The gender distribution of the participants indicates a noticeable majority of male participants, constituting 70.2% of the total sample while females accounted for 29.8%. This discrepancy in representation could potentially point toward gender specific trends in the construction domain.

4.1.2 Age group representation

The participants' age distribution offered a diverse perspective. The age group analysis revealed that the majority of participants fell within the 31-50 range, representing 51.0% of the total. Notably, the 25-30 age group accounted for 35.6%, followed by the under-25 group at 7.7%. The older age brackets (51-60 and 60+) constituted a smaller proportion, signifying potential generational differences in the construction industry as depicted in the graph below.

Graph 4.2: Age representation of respondents.



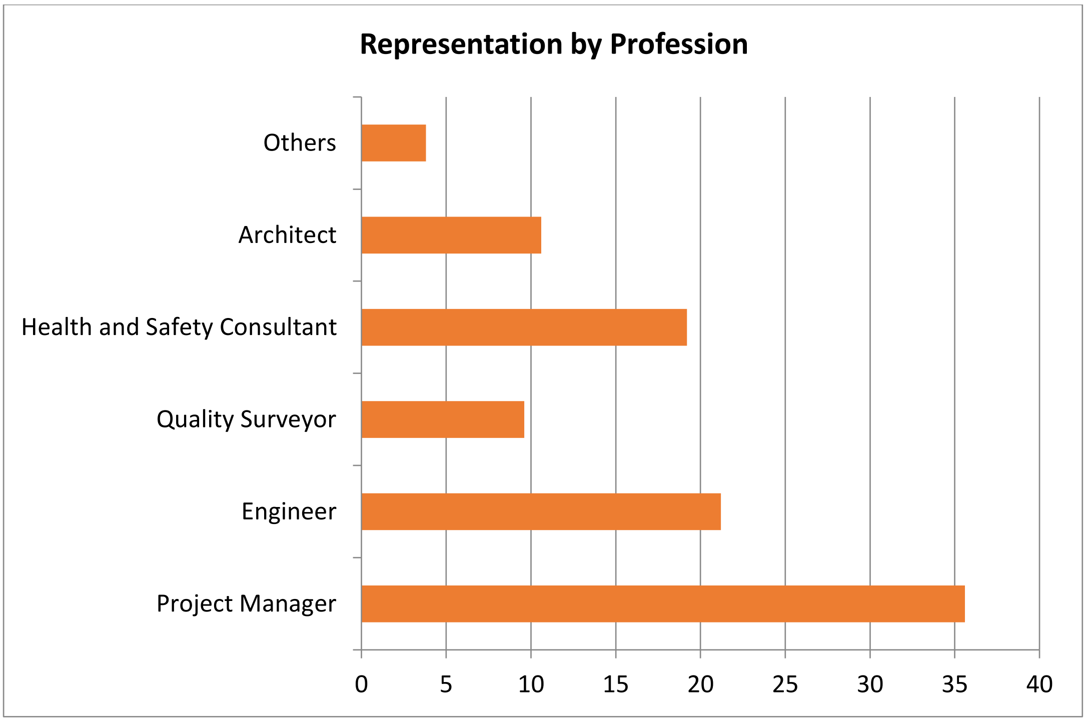
Source: Azola, 2024

4.1.3 Education Attainment

In terms of education, the majority of participants held a bachelor's degree (61.5%) and were closely followed by those with a diploma (14.4%). A significant portion had completed their honours degree (12.5%), while a smaller yet notable number possessed a master's degree (4.8%). This distribution hints at the educational background that contributes to the understanding and application of water conservation practices in construction projects.

4.1.4 Professional Representation

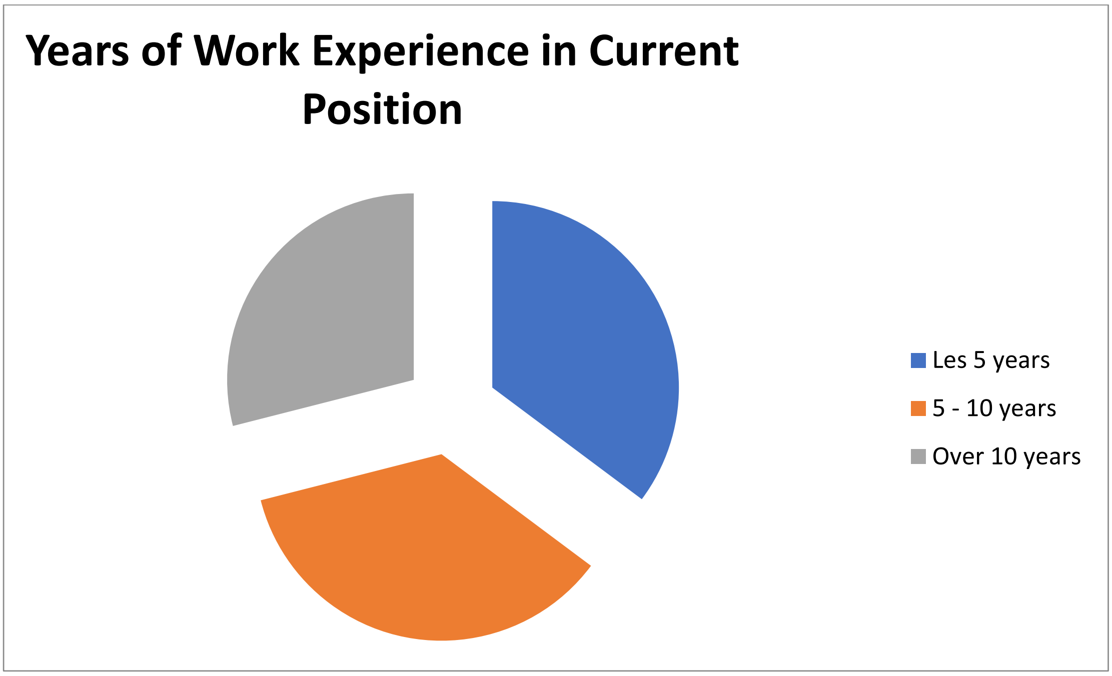
Graph 4.3: Professional representation



Source: Azola,2024

Graph 3 above shows the participants' professional roles and underscores the multifaceted nature of the construction industry. Project managers emerged as the largest group (35.6%), closely followed by engineers (21.2%) and health and safety consultants (19.2%). Quality surveyors (9.6%) and architects (10.6%) also played significant roles. These findings highlight the collaborative nature of water conservation efforts, encompassing a spectrum of expertise.

Graph 4.4 Period of working in the current position



Source: Azola, 2024

The above chart describes the longevity of participants in their current roles, the data unveiled that a substantial portion of participants (39.1%) had been in their positions for 5 to 10 years. Those with less than 5 years of experience constituted 33.7%, while those with over 10 years accounted for 27.2%. This temporal distribution offers insights into the accumulation of experience and its potential impact on water conservation practices.

In addition, participants were asked if they were participants in the local government housing construction projects. The results of the analysis revealed that a significant proportion constituting 79.3% of the sample, affirmed their involvement in such projects. Conversely, 20.7% of the participants indicated that they were not involved in local government housing initiatives. This divergence in participation suggests a notable engagement of professionals in projects led by the local government thereby potentially influencing the implementation of water conservation strategies within these projects.

Overall, the analysis of these demographic factors provides a comprehensive understanding of the participants involved in housing construction projects in Cape Town. These findings lay the groundwork for further exploration of the intricate interplay between demographics, roles and water conservation practices within the construction industry.

4.2 Guidelines for Efficient Water Use and Conservation

In the pursuit of comprehending the strategies employed for efficient water use and conservation within the construction of housing projects in Cape Town South Africa, the analysis delved into participants' perceptions and practices concerning various guidelines. This section discusses the findings from the responses to the questionnaire and explores their alignment with the existing literature.

The participants were presented with a series of statements regarding guidelines for efficient water use and conservation in housing construction projects. The responses were measured on a scale ranging from "strongly disagree (1)" to "strongly agree (5)", along with an "unsure, (6)" option. These findings are presented in Table 4.2.1 below.

Table 4.2.1: THE GUIDELINES FOR EFFICIENT USE AND CONSERVATION OF FRESHWATER IN THE CONSTRUCTION OF HOUSING PROJECTS

Statements	No	Strongly disagree (%)	Disagree (%)	Somewhat agree (%)	Agree (%)	Strongly agree (%)	Unsure (%)
We use a builder's guidebook for reference on efficient use of freshwater on construction sites.	204	17,3	24,0	6,7	17,6	28,8	3,8
We observe environmental policies regarding water conservation on construction sites.	204	6,7	11.5	19,2	40,4	22,1	0,0
We use licensed water abstraction system on construction sites	204	19,2	23,1	21,2	24,0	12,5	0,0

to reduce water wastage							
Municipality increases water rates on construction sites as a control measure to prevent wasteful practices.	204	1,9	2,9	3,8	13,5	34,6	43,3
Construction sites use integrated water efficient techniques during the pre-design and tender stage.	204	4,8	3,8	20,2	16,3	49,0	5,8
We use a water action plan at the inception of construction	204	10,6	4,8	45,2	22,1	15,4	1,9
We implement rainwater collection and reuse	204	36,5	4,8	19,2	12,5	25,0	1,9
We introduce sub-metering systems for the construction projects	204	9,6	3,8	19,2	13,5	48,1	5,8
We implement water auditing to	204	39,4	13,5	2,9	5,8	32,7	5,8

account for water losses							
We introduce water leak detection and monitoring systems to account for water losses	204	18,3	24,0	11,5	9,6	35,6	1,0

The findings presented in Table 4.2.1 above illustrate various perspectives on efficient water use and conservation among participants. A significant portion (28.8%) strongly agreed on using a builder's guidebook for efficient water use, reflecting an understanding of its importance, however, 24.0% disagreed or strongly disagreed, indicating a potential gap in awareness or implementation compared to international recommendations. Regarding the observance of environmental policies on water conservation, a substantial percentage (40.4%) agreed, while 11.5% disagreed, prompting further investigation into reasons for non-compliance. Responses regarding the usage of licensed water abstraction systems were evenly distributed, with 24.0% agreeing and 23.1% disagreeing, indicating a divided perspective within the construction sector. The idea that high water rates can act as a control measure received substantial agreement (34.6%), although a small percentage (2.9%) disagreed, consistent with previous studies suggesting scepticism about the effectiveness of pricing in behavioural change. Overwhelming agreement (49.0%) on employing integrated water-efficient techniques during pre-design and tender stages underscores the importance of sustainable planning, although a small percentage (3.8%) disagreed. While a significant portion (45.2%) agreed on introducing a water action plan at construction inception, 10.6% disagreed, reflecting varying perceptions of necessity. Implementing rainwater collection and reuse garnered agreement from 25.0%, but a substantial percentage (36.5%) strongly disagreed, suggesting barriers to adoption that need addressing. The introduction of sub-metering systems received substantial support (48.1%), although a small percentage (9.6%) disagreed, hinting at potential implementation concerns. Responses were diverse regarding water auditing implementation, with 32.7% in agreement and 39.4% strongly disagreeing, highlighting the complexities involved. While there was substantial agreement (35.6%) on the introduction of water leak detection and monitoring systems, 24.0% disagreed, indicating a need for better communication of benefits.

Table 4.2.2 THE GUIDELINES FOR EFFICIENT USE AND CONSERVATION OF FRESHWATER IN CONSTRUCTION

Item	Section 1: Guidelines for efficient use and conservation of freshwater in construction.	N	Minimum	Maximum	Mean	Std. Deviation
2.1	We use a builder’s guidebook for reference on efficient use of freshwater on construction sites.	204	1	6	3,28	1,61
2.2	We observe environmental policies regarding water conservation on construction sites.	204	1	1	3,60	1,15
2.3	We use a licensed water abstraction system on construction sites to reduce water wastage.	204	2	6	3,88	1,32
2.4	Municipality increases water rates on construction sites as a control measure to prevent wasteful practices.	204	1	6	5,06	1,14
2.5	Construction sites use integrated water efficient techniques during the pre-design and tender stage.	204	1	6	4,18	1,22
2.6	We use a water action plan at the inception of construction	204	1	6	3,33	1,18
2.7	We implement rainwater collection and reuse	204	1	6	2,90	1,68
2.8	We introduce sub-metering systems for the construction projects	204	1	6	4,04	1,39
2.9	We implement water auditing to account for water losses	204	1	6	2,96	1,91
2.10	We introduce water leak detection and monitoring systems	204	1	6	3,23	1,60

Table 4.2.2 above shows the mean scores for guidelines for efficient use and conservation of freshwater in construction ranged from "strongly disagree (1)", "disagree (2)", “somewhat agree (3)”, “agree (4)”, “strongly agree (5)” and “unsure (6)”.

Item 2.1: This item assesses the extent to which construction practices rely on established guidelines for the efficient use of freshwater. With a mean score of 3.28 and a standard deviation of 1.61, the responses indicate moderate agreement among participants regarding the utilization of builder’s guidebooks for reference. The mean value suggests that, on average, participants perceive the use of guidebooks as somewhat beneficial in promoting efficient freshwater usage in construction activities. However, the relatively high standard deviation implies a notable degree of variability in responses, indicating differing levels of reliance on such resources among participants.

Item 2.2: This item gauges adherence to environmental policies aimed at water conservation within construction practices. The mean score of 3.60 and standard deviation of 1.15 reflect a relatively high level of agreement among participants regarding the observance of environmental policies. The mean value suggests that, on average, participants strongly endorse the importance of adhering to such policies for water conservation efforts in construction. The low standard deviation indicates a relatively consistent agreement among participants, implying a widespread acknowledgment of the significance of environmental regulations in guiding water usage practices.

Item 2.3: Assessing the utilization of licensed water abstraction systems to mitigate water wastage, this item demonstrates a mean score of 3.88 and a standard deviation of 1.32. The mean value suggests a moderate level of agreement among participants regarding the adoption of licensed water abstraction systems. On average, participants perceive such systems as beneficial in reducing water wastage on construction sites. However, the relatively high standard deviation indicates variability in responses, implying differing levels of implementation and awareness regarding licensed water abstraction systems among participants.

Item 2.4: This item evaluates perceptions regarding the effectiveness of municipal interventions, such as increasing water rates, to deter wasteful practices on construction sites. With a mean score of 5.06 and a standard deviation of 1.14, participants demonstrate strong agreement on the efficacy of this control measure. The high mean value suggests that, on average, participants strongly endorse the idea of using increased water rates as a mechanism to discourage wasteful practices. Additionally, the low standard deviation indicates a high level of consensus among participants, implying widespread support for this regulatory approach within the construction industry.

Item 2.5: This item assesses the extent to which construction sites incorporate integrated water-efficient techniques during the pre-design and tender stages of projects. The mean score of 4.18 and standard deviation of 1.22 indicate a moderate level of agreement among participants regarding the implementation of such techniques. On average, participants perceive the adoption of integrated water-efficient techniques during project planning as beneficial. However, the relatively high standard deviation suggests variability in responses, indicating differing levels of awareness and adoption of these techniques among construction sites.

Item 2.6: This item evaluates the implementation of water action plans at the beginning of construction projects. With a mean score of 3.33 and a standard deviation of 1.18, participants demonstrate moderate agreement regarding the utilization of water action plans. The mean value suggests that, on average, participants recognize the importance of initiating water conservation efforts early in the construction process. However, the standard deviation indicates variability in responses, implying differences in the extent to which water action plans are integrated into construction practices.

Item 2.7: This item gauges the implementation of rainwater collection and reuse practices on construction sites. With a mean score of 2.90 and a relatively high standard deviation of 1.68, participants demonstrate mixed perceptions regarding the adoption of this water conservation strategy. The mean value indicates a tendency towards disagreement with the implementation of rainwater collection and reuse, suggesting that, on average, participants are less inclined to adopt these practices. The high standard deviation suggests significant variability in responses, indicating diverse opinions and practices regarding rainwater harvesting among construction sites.

Item 2.8: This item assesses the introduction of sub-metering systems to monitor water usage in construction projects. With a mean score of 4.04 and a standard deviation of 1.39, participants exhibit moderate agreement regarding the implementation of sub-metering systems. The mean value suggests that, on average, participants view the introduction of these systems favourably as a means of monitoring and managing water consumption. However, the standard deviation indicates variability in responses, reflecting differences in the extent to which sub-metering systems are adopted across construction projects.

Item 2.9: This item evaluates the implementation of water auditing practices to track and mitigate water losses on construction sites. With a mean score of 2.96 and a high standard deviation of 1.91, participants demonstrate mixed perceptions regarding the adoption of water auditing. The mean value indicates a tendency towards disagreement with the implementation of water auditing, suggesting that, on average, participants are less inclined to conduct these assessments. The high standard deviation suggests significant variability in responses, indicating diverse attitudes towards water auditing practices among construction sites.

Item 2.10: This item assesses the introduction of water leak detection and monitoring systems to identify and address water leaks on construction sites. With a mean score of 3.23 and a standard deviation of 1.60, participants demonstrate moderate agreement regarding the implementation of these systems. The mean value suggests that, on average, participants perceive the introduction of water leak detection and monitoring systems positively. However, the standard deviation indicates variability in responses, reflecting differences in the extent to which these systems are adopted and utilized across construction projects.

4.3: Sources of Water Used in Housing Construction Projects

The analysis aimed to examine the prevailing practices and perceptions of participants in relation to the sources of water in housing construction projects within Cape Town. Table 4.3.1 below presents the questionnaire findings.

Table 4.3.1: SOURCES OF WATER USED IN HOUSING CONSTRUCTION PROJECTS

Statements	No.	Strongly disagree (%)	Disagree (%)	Somewhat agree (%)	Agree (%)	Strongly agree (%)	Unsure (%)
We source construction water from fresh tapped water	204	10,6	1,9	8,7	16,3	55,8	6,7
We use grey waste water sources for making concrete.	204	54,8	11,5	6,7	2,9	16,3	7,7
We sometimes harvest rainwater as a source of water and use for washing tools, mixing cement and dust suppression.	204	12,5	4,8	16,3	15,4	49,0	1,9
We use low-pressure alternatives for cleaning on construction sites.	204	14,4	7,7	4,8	47,1	19,2	6,7
We use misting or atomising systems that use minimal water which	204	58,7	9,6	4,8	5,8	9,6	11,5

are more effective at dust suppression							
We have a reservoir of water that construction workers use to clean heavy machinery and vehicles, instead of running tap water	204	11,5	23,1	23,1	4,8	8,7	27,9
We use reclaimed waste water for some of the activities on construction sites	204	10,6	29,8	18,3	14,4	23,1	1,9

The findings presented in Table 4.3.1 above illustrate the sources of water used in housing construction projects in Cape Town and reveals diverse attitudes and practices among participants. The majority of participants (55.8%) strongly agreed on using freshwater taps as a water source for construction activities, underscoring the prevalence of freshwater usage in construction, aligning with existing literature highlighting the significant water consumption in the construction sector throughout project lifecycles. Responses regarding grey wastewater utilization were mixed, with a notable percentage (54.8%) strongly disagreeing, yet 16.3% agreed, recognizing the potential environmental and cost benefits of greywater reuse in construction activities. Rainwater harvesting for construction activities received significant support, with 49.0% strongly agreeing on its employment for tasks such as tool washing and dust suppression, indicating the potential for sustainable water use practices in construction projects. The usage of low-pressure alternatives for cleaning garnered significant agreement (47.1%), reflecting a leaning towards water-efficient practices among participants. However, responses regarding water-efficient dust suppression strategies were diverse, with a majority (58.7%) strongly disagreeing, although 19.2% agreed, indicating varying perceptions of the efficacy of sustainable dust suppression methods. Views on reservoir usage for cleaning heavy machinery varied among participants, suggesting differing practices influenced by feasibility and practicality considerations. The use of reclaimed wastewater in construction prompted a mixed response, with 29.8% disagreeing and 23.1% agreeing, reflecting the complexities in promoting sustainable water use in construction and the need for greater understanding and management of water consumption during construction activities.

Table 4.3.2: MEAN SCORES FOR SOURCES OF WATER USE IN HOUSING CONSTRUCTION PROJECTS

Item	The sources of water used in housing construction projects in Cape Town.	N	Minimum	Maximum	Mean	Std. Deviation
3.1	We source construction water from fresh tapped water	204	1	6	2,90	1,68
3.2	We use grey wastewater sources for making concrete	204	1	6	3,89	1,48
3.3	We sometimes harvest rainwater as a source of water for washing tools, mixing cement and dust suppression.	204	1	6	2,38	1,82
3.4	We use low-pressure alternatives for cleaning on construction sites.	204	1	6	3,16	1,41
3.5	We use misting or atomising systems that use minimal water which are more effective at dust suppression.	204	1	6	4,25	1,38
3.6	We have a reservoir of water that construction workers use to clean heavy machinery and vehicles, instead running tap water	204	1	6	3,69	1,43
3.7	We use reclaimed wastewater for some of the activities on construction sites	204	1	6	2,05	1,44

Item 3.1: This item evaluates the utilization of fresh tapped water as a source of construction water in housing construction projects in Cape Town. With a mean score of 2.90 and a standard deviation of 1.68, participants demonstrate mixed perceptions regarding the use of fresh tapped water. The mean value suggests a tendency towards disagreement with sourcing construction water from fresh tapped water, indicating that, on average, participants are less inclined to utilize this water source. The relatively high standard deviation indicates significant variability in responses, reflecting diverse opinions and practices regarding the use of fresh tapped water in construction projects.

Item 3.2: This item assesses the use of grey wastewater sources for making concrete in housing construction projects. With a mean score of 3.89 and a standard deviation of 1.48, participants demonstrate moderate agreement with the utilization of grey wastewater for making concrete. The mean value indicates a tendency towards agreement with this practice, suggesting that, on average, participants view the use of grey wastewater positively as a source of water for concrete production. The standard deviation reflects variability in responses, indicating differing attitudes towards the use of grey wastewater among construction projects.

Item 3.3: This item gauges the occasional harvesting of rainwater for various construction activities. With a mean score of 2.38 and a high standard deviation of 1.82, participants demonstrate mixed perceptions regarding the utilization of rainwater harvesting. The mean value indicates a tendency towards disagreement with the practice of harvesting rainwater, suggesting that, on average, participants are less inclined to adopt this water source. The high standard deviation suggests significant variability in responses, reflecting diverse opinions and practices regarding rainwater harvesting among construction sites.

Item 3.4: This item examines the use of low-pressure alternatives for cleaning purposes on construction sites. With a mean score of 3.16 and a standard deviation of 1.41, participants demonstrate moderate agreement with the adoption of low-pressure cleaning alternatives. The mean value indicates a tendency towards agreement with this practice, suggesting that, on average, participants view low-pressure alternatives favourably for cleaning activities. The standard deviation reflects variability in responses, indicating differing levels of adoption and acceptance of low-pressure cleaning methods among construction projects.

Item 3.5: This item assesses the utilization of misting or atomizing systems for dust suppression purposes, considering their efficiency in water usage. With a mean score of 4.25 and a standard deviation of 1.38, participants demonstrate strong agreement with the use of misting or atomizing systems. The mean value indicates a strong tendency towards agreement with this practice, suggesting that participants overwhelmingly endorse the adoption of such systems for dust suppression. The relatively low standard deviation indicates a higher level of consensus among participants regarding the effectiveness and desirability of misting or atomizing systems.

Item 3.6: This item evaluates the use of reservoir water for cleaning heavy machinery and vehicles on construction sites as an alternative to tap water. With a mean score of 3.69 and a standard deviation of 1.43, participants demonstrate moderate agreement with this practice. The mean value indicates a tendency towards agreement with the use of reservoir water, suggesting that participants generally perceive it as a viable alternative to tap water for cleaning purposes. The standard deviation reflects variability in responses, indicating differing levels of adoption and acceptance of reservoir water among construction projects.

Item 3.7: This item examines the utilization of reclaimed wastewater for various activities on construction sites. With a mean score of 2.05 and a standard deviation of 1.44, participants demonstrate mixed perceptions regarding the use of reclaimed wastewater. The mean value indicates a tendency towards disagreement with the practice of using reclaimed wastewater, suggesting that participants are generally less inclined to adopt this water source. The standard deviation reflects significant variability in responses, indicating diverse opinions and practices regarding the use of reclaimed wastewater among construction projects.

4.4 Water Conservation Methods in Housing Construction

The participants' viewpoints concerning the utilization of water conservation methods during housing construction projects were probed through a series of statements. Responses were rated using a scale from "strongly disagree (1)" to "strongly agree (5)," with the addition of an "unsure (6)" option. The outcomes of this exploration are encapsulated in Table 4.4.1 below.

Table 4.4.1 WATER CONSERVATION METHODS USED

Statements	No	Strongly disagree (%)	Disagree (%)	Somewhat agree (%)	Agree (%)	Strongly agree (%)	Unsure (%)
We use dust suppression vehicles with sprinklers	204	20,2	22,1	5,8	19,2	31,7	1,0
We use efficient showers with low-flow showerheads	204	26,9	22,1	5,8	28,8	13,5	2,9
We use fan misting systems for dust suppression	204	58,7	7,7	14,4	9,6	8,7	1,0
We use high pressure trigger operated spray gun hoses	204	11,5	9,6	27,9	11,5	37,5	1,9
We use efficient showers with low-flow showerheads	204	7,7	19,2	22,1	8,7	40,4	1,9
We use pressure reducing valves in construction of housing projects	204	8,7	24,0	10,6	11,5	44,2	1,0

We use water sprinkler systems for curing concrete to reduce water wastage	204	35,6	9,6	4,8	19,2	30,8	0,0
We use vacuum toilets to ensure efficient water use	204	33,7	11,5	10,6	17,3	24,0	2,9
We use a washing bay for wheel washing in order to conserve water use	204	7,7	8,7	14,4	11,5	51,0	6,7
We use water efficient taps to control water wastage	204	5,8	7,7	26,9	49,0	5,8	0,0

The analysis above delved into participants' viewpoints on the utilization of water conservation methods during housing construction projects. Responses were collected using a scale ranging from "strongly disagree (1)" to "strongly agree (5)," along with an "unsure (6)" option. Approximately 31.7% of participants strongly agreed on employing dust suppression vehicles equipped with sprinklers, indicating awareness of their effectiveness in curbing water wastage during construction activities. However, 20.2% strongly disagreed, suggesting potential room for improved adoption. Responses regarding efficient showers equipped with low-flow showerheads were diverse. Around 28.8% expressed agreement, potentially indicating recognition of the benefits in terms of water conservation. Conversely, 26.9% strongly disagreed, highlighting the need for broader awareness of the advantages. Opinions on fan misting systems for dust suppression varied, with 14.4% somewhat agreeing. However, 58.7% strongly disagreed, possibly due to scepticism or limited familiarity with this approach. High-pressure trigger-operated spray gun hoses found favour among participants, with 37.5% strongly agreeing with their usage. Nonetheless, 27.9% somewhat agreed, indicating a nuanced perspective within the construction community. The utilization of low flush cisterns, urinals and waterless urinals gained significant support, with 40.4% strongly agreeing with their implementation. Nevertheless, 22.1% disagreed, suggesting the need for further education and encouragement. Pressure-reducing valves found resonance among participants, as 44.2% strongly agreed with their usage. Conversely, 24.0% expressed disagreement, pointing towards varying perspectives on their effectiveness. The use of water sprinkler systems for curing concrete prompted mixed reactions, with 30.8% somewhat agreeing. However, 35.6% strongly disagreed, potentially reflecting concerns over water wastage in such practices. Usage of vacuum toilets for efficient water use evoked diverse responses, with 24.0% agreeing and 33.7% expressing disagreement, suggesting reservations or a lack of awareness. The concept of using a washing bay for wheel washing to conserve water found substantial backing, with 51.0% strongly agreeing. However, 14.4% somewhat disagreed, indicating room for discourse on its practicality. Water-efficient taps emerged as a popular approach, with 49.0% strongly agreeing to their usage. This widespread endorsement reflects recognition of their potential in curbing wastage.

Table 4.4.2: MEAN SCORE ON WATER EFFICIENT AND CONSERVATION METHODS IN CONSTRUCTION OF HOUSING PROJECTS.

Item	Methods of water use efficiency and conservation in the construction of housing projects in Cape Town.	N	Minimum	Maximum	Mean	Std. Deviation
3.1	We use dust suppression vehicles with sprinklers	204	1	1	3,60	1,14
3.2	We use efficient showers with low-flow showerheads	204	1	6	5,06	1,15
3.3	We use fan misting systems for dust suppression	204	1	6	4,18	1,22
3.4	We use high pressure trigger operated spray gun hoses	204	1	6	3,33	1,18
3.5	We low flush cisterns/urinals/waterless urinals in construction of housing projects	204	1	6	2,90	1,68
3.6	We use pressure reducing valves in construction of housing projects	204	1	6	4,04	1,39
3.7	We use water sprinkler systems for curing concrete to reduce water wastage	204	1	6	3,69	1,43
3.8	We use vacuum toilets to ensure efficient water use	204	1	6	3,60	1,82
3.9	We use a washing bay for wheel washing in order to conserve water use	204	1	6	3,23	1,60
3.10	We use water efficient taps to control water wastage	204	1	6	2,05	1,44

Item 3.1: This item assesses the utilization of dust suppression vehicles equipped with sprinklers in construction projects. With a mean score of 3.60 and a standard deviation of 1.14, participants demonstrate moderate agreement with the use of such vehicles. The mean value indicates a tendency towards agreement with this practice, suggesting that participants

generally perceive dust suppression vehicles with sprinklers as effective tools for reducing water wastage during construction activities. The low standard deviation reflects a higher level of consensus among participants regarding the adoption of this method.

Item 3.2: This item evaluates the use of efficient showers equipped with low-flow showerheads in construction projects. With a mean score of 5.06 and a standard deviation of 1.15, participants demonstrate strong agreement with the adoption of such showers. The mean value indicates a strong tendency towards agreement with this practice, suggesting that participants overwhelmingly endorse the use of efficient showers with low-flow showerheads for water conservation. The low standard deviation indicates a higher level of consensus among participants regarding the effectiveness and desirability of this water-saving measure.

Item 3.3: This item examines the utilization of fan misting systems for dust suppression purposes on construction sites. With a mean score of 4.18 and a standard deviation of 1.22, participants demonstrate moderate agreement with the use of such systems. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive fan misting systems as effective tools for dust suppression. The moderate standard deviation reflects some variability in responses, indicating differing levels of adoption and acceptance of this method among construction projects.

Item 3.4: This item assesses the use of high-pressure trigger-operated spray gun hoses in construction projects. With a mean score of 3.33 and a standard deviation of 1.18, participants demonstrate moderate agreement with the adoption of such hoses. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive high-pressure trigger-operated spray gun hoses as effective tools for water conservation. The moderate standard deviation reflects some variability in responses, indicating differing levels of adoption and acceptance of this method among construction projects.

Item 3.5: This item evaluates the use of low flush cisterns, urinals or waterless urinals in housing construction projects. With a mean score of 2.90 and a standard deviation of 1.68, participants demonstrate moderate agreement with the adoption of these water-saving fixtures. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive the use of low flush fixtures as beneficial for water conservation. The high standard deviation reflects significant variability in responses, indicating diverse opinions and practices regarding the adoption of these fixtures among construction projects.

Item 3.6: This item assesses the utilization of pressure reducing valves in housing construction projects. With a mean score of 4.04 and a standard deviation of 1.39, participants demonstrate moderate agreement with the adoption of pressure reducing valves. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive pressure reducing valves as effective tools for water conservation. The moderate standard deviation reflects some variability in responses, indicating differing levels of adoption and acceptance of this method among construction projects.

Item 3.7: This item examines the use of water sprinkler systems for curing concrete in construction projects. With a mean score of 3.69 and a standard deviation of 1.43, participants demonstrate moderate agreement with the use of such systems. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive water sprinkler systems as effective tools for reducing water wastage during concrete curing. The moderate standard deviation reflects some variability in responses, indicating differing levels of adoption and acceptance of this method among construction projects.

Item 3.8: This item evaluates the use of vacuum toilets in construction projects to ensure efficient water use. With a mean score of 3.60 and a standard deviation of 1.82, participants demonstrate moderate agreement with the adoption of vacuum toilets. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive vacuum toilets as effective tools for water conservation. The high standard deviation reflects significant variability in responses, indicating diverse opinions and practices regarding the adoption of vacuum toilets among construction projects.

Item 3.9: This item assesses the use of washing bays for wheel washing in construction projects to conserve water. With a mean score of 3.23 and a standard deviation of 1.60, participants demonstrate moderate agreement with the adoption of washing bays. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive washing bays as effective tools for water conservation. The moderate standard deviation reflects some variability in responses, indicating differing levels of adoption and acceptance of this method among construction projects.

Item 3.10: This item evaluates the use of water-efficient taps in construction projects to control water wastage. With a mean score of 2.05 and a standard deviation of 1.44, participants demonstrate moderate agreement with the adoption of water-efficient taps. The mean value indicates a tendency towards agreement with this practice, suggesting that participants generally perceive water-efficient taps as effective tools for water conservation. The high standard deviation reflects significant variability in responses, indicating diverse opinions and practices regarding the adoption of water-efficient taps among construction projects.

4.5 Challenges in Implementing Sustainable Water Conservation Methods

This study delves into the challenges encountered while attempting to implement sustainable water conservation methods within housing construction projects in Cape Town. The data collected from participant responses is complemented by insights drawn from existing literature.

TABLE 4.5.1: CHALLENGES OF IMPLEMENTATION OF SUSTAINABLE WATER CONSERVATION

Statements	**No.**	**Strongly disagree**	**Disagree**	**Somewhat agree**	**Agree**	**Strongly agree**	**Unsure**
There is lack of policies and planning for water conservation	204	1,9	1,9	17,3	33,7	45,2	0,0
There is lack of positive attitude and behaviour of site workers towards water conservation	204	1,9	11,5	13,5	14,4	57,7	1,0
There is lack of alternative housing construction methods	204	1,9	17,3	12,5	33,7	31,7	2,9
There is lack of efficient technologies necessary for conserving water use during housing construction	204	5,8	3,8	18,3	29,8	41,3	1,0
There is lack of monitoring and targeting of water use	204	13,5	4,6	27,9	8,7	43,3	1,9
There is lack of water audit policy to determine the amount of water loss due to leakage	204	19,2	1,0	22,1	8,7	42,3	5,8

The findings presented in Table 4.5.1 above illustrate that a lack of policies and planning for water conservation emerged as a noteworthy challenge, with a substantial 45.2% strongly agreeing, underlining the perceived absence of a structured framework to guide water conservation efforts. This resonates with prior research that underscores the importance of policy support. Negative attitudes and behaviours of site workers towards water conservation posed a significant obstacle, with 57.7% strongly agreeing, signifying a prevalent recognition of these behavioural challenges. This result aligns with research highlighting the pivotal role of attitudes in shaping conservation behaviour. The lack of alternative housing construction methods was another noteworthy challenge, with around 33.7% agreeing, suggesting a nuanced acknowledgment of this barrier. However, 31.7% expressed strong agreement, possibly indicating a belief in the potential of alternative methods to enhance water efficiency. Insufficient access to efficient technologies essential for water conservation emerged as a considerable challenge, with a notable 41.3% strongly agreeing, underscoring the perceived deficiency in technological support. This result corresponds with prior literature that emphasizes the role of technology in water conservation. The lack of monitoring and targeting mechanisms for water use during construction projects surfaced as a substantial challenge, with 43.3% strongly agreeing, suggesting an awareness of the importance of tracking and regulating water consumption. Conversely, 27.9% expressed agreement, indicating a diversity of perspectives. The absence of a water audit policy to determine the extent of water loss due to leakage also posed a considerable challenge, with 42.3% strongly agreeing, possibly indicating a recognition of the significance of minimizing water loss. Conversely, 22.1% somewhat agreed, suggesting room for further dialogue on this issue. These findings shed light on the multifaceted challenges faced in implementing sustainable water conservation methods in construction projects, emphasizing the need for comprehensive strategies and policy frameworks.

Table 4.5.2: MEAN SCORE ON CHALLENGES IN IMPLEMENTING SUSTAINABLE WATER CONSERVATION MEASURES

Item	Challenges in implementation of sustainable water conservation methods during housing construction	N	Minimum	Maximum	Mean	Std. Deviation
4.1	There is lack of policies and planning for water conservation	204	1	5	4,18	,92

4.2	There is lack of positive attitude and behaviour of site workers towards water conservation	204	5	6	3,17	1,17
4.3	There is lack of alternative housing construction methods	204	1	6	3,85	1,19
4.4	There is lack of efficient technologies necessary for conserving water use during housing construction	204	1	6	4,0	1,15
4.5	There is lack of monitoring and targeting of water use	204	1	6	3,69	1,46
4.6	There is lack of water audit policy to determines the amount of water loss due to leakage	204	1	6	3,72	1,62

Item 4.1: This item explores the perceived absence of policies and planning for water conservation during housing construction. With a mean score of 4.18 and a standard deviation of 0.92, participants indicate a high level of agreement with this challenge. The high mean value suggests that participants strongly perceive a deficiency in policies and planning aimed at water conservation. The relatively low standard deviation indicates a relatively consistent agreement among participants regarding this challenge, reflecting a widespread acknowledgment of the need for improved policies and planning in the construction industry.

Item 4.2: This item assesses the lack of positive attitude and behaviour of site workers towards water conservation efforts. With a mean score of 3.17 and a standard deviation of 1.17, participants demonstrate moderate agreement with this challenge. The mean value suggests a tendency towards agreement among participants regarding the negative attitudes and behaviours of site workers towards water conservation. The moderate standard deviation indicates some variability in responses, reflecting differing perceptions among participants regarding the extent of this challenge.

Item 4.3: This item examines the perceived lack of alternative housing construction methods conducive to water conservation. With a mean score of 3.85 and a standard deviation of 1.19, participants indicate moderate agreement with this challenge. The mean value suggests a tendency towards agreement among participants regarding the insufficiency of alternative construction methods. The moderate standard deviation indicates some variability in responses, reflecting differing levels of awareness and acceptance of alternative methods among participants.

Item 4.4: This item evaluates the perceived lack of efficient technologies necessary for conserving water use in housing construction. With a mean score of 4.0 and a standard deviation of 1.15, participants demonstrate moderate agreement with this challenge. The mean value suggests a tendency towards agreement among participants regarding the inadequacy of efficient technologies. The moderate standard deviation indicates some variability in responses, reflecting diverse opinions among participants regarding the availability and effectiveness of water conservation technologies.

Item 4.5: This item assesses the perceived lack of monitoring and targeting of water use during housing construction. With a mean score of 3.69 and a standard deviation of 1.46, participants indicate moderate agreement with this challenge. The mean value suggests a tendency towards agreement among participants regarding the deficiencies in monitoring and targeting water use. The relatively high standard deviation indicates considerable variability in responses, reflecting differing perceptions among participants regarding the extent of monitoring and targeting practices.

Item 4.6: This item examines the perceived absence of a water audit policy to determine water loss due to leakage. With a mean score of 3.72 and a standard deviation of 1.62, participants demonstrate moderate agreement with this challenge. The mean value suggests a tendency towards agreement among participants regarding the absence of water audit policies. The relatively high standard deviation indicates significant variability in responses, reflecting diverse opinions among participants regarding the necessity and effectiveness of water audit policies.

4.6 Strategies towards Water Conservation in Housing Construction

TABLE 4.6.1: STRATEGIES FOR WATER CONSERVATION

Statements	**No.**	**Strongly disagree**	**Disagree**	**Somewhat agree**	**Agree**	**Strongly agree**	**Unsure**
Are there policies in place to integrate water efficiency during construction of housing projects?	204	2,9	19,2	31,7	12,5	30,8	1,9

Do you believe there is a need to introduce a water action plan such as rainwater collection for use for housing construction?	204	3,8	1,0	16,3	69,2	1,9	0,0
Is there a need to introduce water leak detection and monitoring systems?	204	1,9	7,7	18,3	71,2	1,0	0,0
Is there is a need to assign responsibility and targets to the site staff for the conservation of water on construction sites?	204	1,0	2,9	13,5	23,1	58,7	1,0
Is there is a need to improve monitoring and supervision of site staff to ensure they practice water conservation methods?	204	1,0	11,5	3,8	25,0	57,7	1,0
Is there a need to increase water conservation awareness among site workers?	204	1,0	15,4	1,9	13,5	67,3	1,0
Is there a need to implement closed loop systems to regulate water use during housing construction?	204	1,0	1,0	7,7	12,5	76,0	1,9
Is there a need to introduce dry wall partitions instead of brick and block walls in order to minimise water use in construction?	204	1,0	6,7	15,4	11,5	60,6	3,8

Is it best for construction firms to adopt the use of steel intensive construction methods as an alternative?	204	16,3	24,0	9,6	48,1	1,9	0,0
Is it best to adopt the use of pre-mixed concrete and pre-mixed mortar as the alternative?	204	1,9	19,2	12,5	12,5	51,9	2,0

The findings presented in Table 4.6.1 above show opinions of participants regarding various strategies aimed at enhancing water conservation during housing construction that were captured through their statements. Participants rated these strategies using a scale spanning from "strongly disagree (1)" to "strongly agree (5)," with an "unsure (6)" option provided. The outcomes of this exploration are summarized in Table 4.6.1 The presence of policies to integrate water efficiency was explored. Notably, 30.8% strongly agreed that these policies exist, signifying a level of awareness regarding the role of regulations in promoting water conservation. However, contrasting perspectives emerged, with 31.7% somewhat agreeing, revealing diverse perceptions of policy effectiveness. The proposition to introduce water action plans, such as rainwater collection, received robust agreement, with a significant 69.2% agreeing, highlighting widespread support for practical initiatives to conserve water. This corresponds with literature that emphasizes the significance of action plans and rainwater harvesting in promoting water efficiency. The need to allocate responsibility and targets to site staff for water conservation gained substantial approval, with 71.2% agreeing, indicating a recognition of the importance of personal accountability in fostering conservation behaviour. This aligns with scholarly insights that underscore the role of behavioural change in water use efficiency. The idea of implementing penalties against unacceptable practices received strong endorsement, with a notable 58.7% strongly agreeing, suggesting a consensus on the efficacy of punitive measures in deterring wasteful behaviours. The need to enhance monitoring and supervision was met with substantial support, as 57.7% strongly agreed, indicating a consensus on the role of oversight in ensuring efficient water use during construction. The call to increase water conservation awareness among site workers was widely acknowledged, with 67.3% strongly agreeing, underlining the perceived significance of education and awareness campaigns. This mirrors insights that highlight the role of awareness in shaping conservation behaviour. The proposal to implement closed loop systems to regulate water use garnered robust endorsement, with a significant 76.0% strongly agreeing, indicating a shared belief in the effectiveness of technological solutions for efficient water management. This corresponds with prior literature that underscores the potential of closed loop systems. The adoption of alternative construction methods, such as drywall partitions and steel-intensive approaches, garnered diverse perspectives, with 60.6% agreeing with the use of drywall partitions and 48.1% agreeing with the adoption of steel-intensive methods. These findings highlight a nuanced consideration of innovative construction techniques.

Table 4.6.2: MEAN SCORE ON STRATEGIES TO IMPROVE SUSTAINABLE WATER USE DURING CONSTRUCTION

Item	Strategies for improving sustainable water use during housing construction	N	Minimum	Maximum	Mean	Std. Deviation
5.1	Are there policies in place to integrate water efficiency during construction of housing projects?	203	1	6	3,55	1,25
5.2	Do you believe there is a need to Introduce water action plan such as rainwater collection for use for housing construction?	202	1	5	4,49	,97
5.3	Is there a need to introduce water leak detection and monitoring systems?	203	1	5	4,58	,80
5.4	Is there is a need to assign responsibility and targets to the site staff for the conservation of water on construction sites?	203	1	5	4,37	,90
5.5	Is there a need to introduce penalty against unacceptable practices by site staff that result in water wastage?	203	1	5	4,28	1,05
5.6	Is there is a need to improve monitoring and supervision of site staff to ensure they practice water conservation methods?	203	1	5	4,32	1,15
5.7	Is there a need to increase water conservation awareness among site workers?	202	1	5	4,65	,75
5.8	Is there a need to implementing closed loop systems to regulate water use during housing construction?	202	1	5	4,67	3,21

5.9	Is there a need to introduce dry wall partitions instead of brick and block walls in order to minimise water use in construction	202	2	5	3,91	1,19
5.10	Is it best for construction firms to adopt the use of steel intensive construction methods as an alternative?	203	1	6	3,97	1,29
5.11	Is it best to adopt the use of pre-mixed concrete and pre-mixed mortar as the alternative?	203	1	5	4,75	,67

Item 5.1: This item examines the existence of policies aimed at integrating water efficiency during housing construction projects. With a mean score of 3.55 and a standard deviation of 1.25, participants indicate moderate agreement with the presence of such policies. The mean value suggests a tendency towards agreement among participants regarding the need for policies promoting water efficiency. The standard deviation indicates some variability in responses, reflecting differing perceptions among participants regarding the effectiveness and implementation of these policies.

Item 5.2: This item assesses the perceived need to introduce water action plans, such as rainwater collection, for housing construction projects. With a mean score of 4.49 and a standard deviation of 0.97, participants demonstrate strong agreement with the necessity of implementing such plans. The high mean value suggests a widespread recognition among participants regarding the importance of incorporating water action plans into construction practices. The relatively low standard deviation indicates a consistent agreement among participants, reflecting a shared belief in the efficacy of these strategies.

Item 5.3: This item evaluates the perceived need to introduce water leak detection and monitoring systems in construction projects. With a mean score of 4.58 and a standard deviation of 0.80, participants indicate strong agreement with the necessity of implementing such systems. The high mean value suggests a widespread acknowledgment among participants regarding the importance of detecting and monitoring water leaks. The low standard deviation indicates consistent agreement among participants, reflecting a shared belief in the effectiveness of these systems for water conservation.

Item 5.4: This item explores the perceived need to assign responsibility and targets to site staff for water conservation efforts. With a mean score of 4.37 and a standard deviation of 0.90, participants demonstrate strong agreement with the importance of assigning such responsibilities. The high mean value suggests a widespread recognition among participants regarding the necessity of fostering accountability among site staff. The relatively low standard deviation indicates consistent agreement among participants, reflecting a shared belief in the effectiveness of this strategy for promoting water conservation.

Item 5.5: This item examines the perceived need to introduce penalties against unacceptable practices leading to water wastage on construction sites. With a mean score of 4.28 and a standard deviation of 1.05, participants indicate strong agreement with the necessity of implementing penalties. The high mean value suggests a widespread recognition among participants regarding the importance of deterring wasteful practices through punitive measures. The standard deviation indicates some variability in responses, reflecting differing opinions among participants regarding the severity and enforcement of penalties.

Item 5.6: This item assesses the perceived need to enhance monitoring and supervision of site staff to ensure adherence to water conservation methods. With a mean score of 4.32 and a standard deviation of 1.15, participants demonstrate strong agreement with the importance of improving monitoring and supervision. The high mean value suggests a widespread acknowledgment among participants regarding the necessity of effective oversight. The standard deviation indicates some variability in responses, reflecting differing perspectives among participants regarding the extent and methods of monitoring and supervision.

Item 5.7: This item explores the perceived need to raise awareness about water conservation among site workers. With a mean score of 4.65 and a standard deviation of 0.75, participants indicate strong agreement with the importance of increasing awareness. The high mean value suggests a widespread recognition among participants regarding the significance of educating site workers about water conservation practices. The low standard deviation indicates consistent agreement among participants, reflecting a shared belief in the efficacy of awareness-raising initiatives.

Item 5.8: This item evaluates the perceived need to implement closed-loop systems for regulating water use during construction. With a mean score of 4.67 and a standard deviation of 3.21, participants demonstrate strong agreement with the importance of adopting such systems. The high mean value suggests a widespread acknowledgment among participants regarding the potential benefits of closed-loop systems for efficient water management. However, the high standard deviation indicates significant variability in responses, reflecting differing opinions and uncertainty regarding the feasibility and effectiveness of these systems.

Item 5.9: This item assesses the perceived benefit of introducing drywall partitions as an alternative construction method to minimize water use. With a mean score of 3.91 and a standard deviation of 1.19, participants indicate moderate agreement with the effectiveness of this approach. The mean value suggests a tendency towards agreement among participants regarding the potential of drywall partitions for water conservation. The standard deviation indicates some variability in responses, reflecting differing opinions and considerations regarding the practicality and impact of adopting this construction method.

Item 5.10: This item examines the perceived benefit of adopting steel-intensive construction methods as an alternative for water conservation. With a mean score of 3.97 and a standard deviation of 1.29, participants demonstrate moderate agreement with the effectiveness of this approach. The mean value suggests a tendency towards agreement among participants regarding the potential of steel-intensive methods for water conservation. The standard deviation indicates some variability in responses, reflecting differing opinions and considerations regarding the feasibility and implications of adopting this construction approach

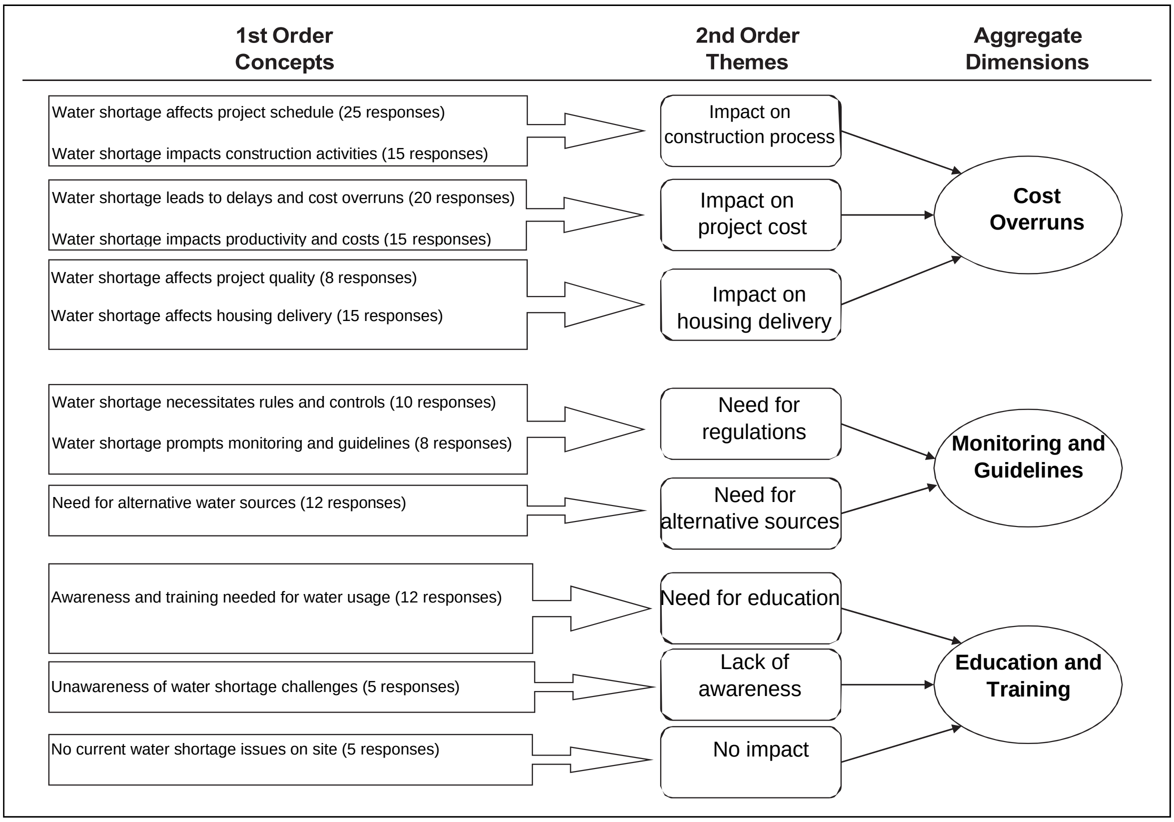
Item 5.11: This item assesses the perceived benefit of adopting pre-mixed concrete and pre-mixed mortar as alternatives in construction. With a mean score of 4.75 and a standard deviation of 0.67, participants strongly agree with the effectiveness of this approach. The high mean value indicates a widespread recognition among participants regarding the potential of pre-mixed materials for water conservation. The low standard deviation suggests consistent agreement among participants, reflecting a shared belief in the efficacy of using pre-mixed concrete and mortar to minimize water use in construction.

In summary, the findings from Section 5 of the questionnaire highlight strong support for various strategies aimed at improving sustainable water use during housing construction in Cape Town. Participants emphasize the importance of policy integration, the implementation of action plans, and the introduction of technological solutions to enhance water efficiency. Additionally, there is widespread agreement on the necessity of assigning responsibility, raising awareness and adopting innovative construction methods to minimize water consumption. These findings underscore the multifaceted nature of water conservation efforts within the construction industry and emphasize the importance of comprehensive strategies to address the challenges associated with water management.

4.7 WATER SHORTAGE CHALLENGE FACED IN CONSTRUCTION OF HOUSING PROJECTS IN CAPE TOWN

This study used open-ended questions to explore the challenges faced as a result of water shortages, as well as the strategies for water conservation in construction of housing projects in Cape Town. The following diagram summarises the responses on the challenges faced in construction of housing projects.

Diagram 4.1 Summary of water shortage challenges faced



The analysis of the participants' responses aimed to determine how the water shortage challenge has impacted the construction of housing projects in Cape Town, South Africa. Responses indicated that water scarcity directly impacts project schedules, leading to delays in delivery and associated cost overruns. Delays in project schedules translate to increased costs, thereby affecting project budgets and overall profitability. The interplay between water scarcity, construction progress and financial implications is a critical consideration for stakeholders in the housing industry.

Responses also touch upon the importance of raising awareness, providing training for water usage and conservation methods on construction sites. Participants' views reflect a proactive approach towards addressing the challenge by promoting mindful consumption practices within the construction industry. Implementing training programmes could foster a collective commitment to sustainability that extends beyond the immediate challenges posed by water shortage.

The responses also emphasize the need for regulations to control water use during housing construction and finding alternative sources of construction water. This finding echoes the wider discourse on the role of policy frameworks in mitigating the impact of water scarcity on various sectors, including construction. Introducing rules that guide water usage practices aligns with the proactive approach recommended by participants.

4.8 Findings on Water Usage in Construction Processes

The study examined the water usage patterns during construction processes on construction sites. The data collected shed light on the frequency of using water trucks and the quantities of water consumed on a regular basis.

Table 4.6.3: Use of water truck for the construction purposes

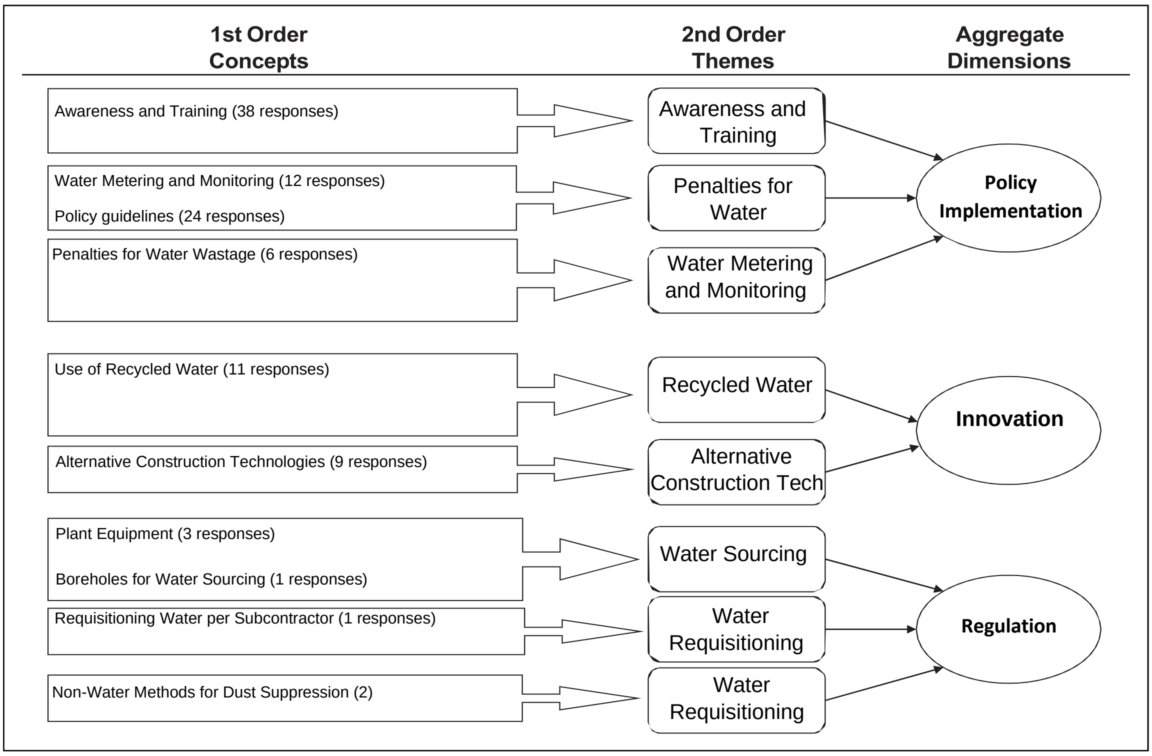
	Frequency	**Percentage**
Often	51	49,0
Never	12	11,5
Seldom	34	32,7
Always	7	6,7
Total	104	100,0

This section examines the water usage patterns during construction processes on construction sites. The data collected shed light on the frequency of using water trucks and the quantities of water consumed on a regular basis. The survey results presented in Table 4.6.3 reveal the frequency of utilizing water trucks for construction purposes, with responses distributed as often (49.0%), never (11.5%), seldom (32.7%), and always (6.7%). This data explicates the extent to which water trucks are integrated into construction activities, emphasizing their crucial role in supplying water for tasks such as concrete mixing, dust control and other construction processes. Participants were also asked about the amount of water used per day, week or month on construction sites, with responses varying from specific figures to more general estimates. The diverse range of responses regarding the quantity of water used reflects the inherent variability in construction practices, influenced by project specifics, activities and site conditions. Understanding the frequency and volume of water usage on construction sites is pivotal for water conservation efforts, highlighting opportunities for optimizing practices to minimize wastage and ensure efficient resource allocation. Moreover, the insights from this section can inform strategies for managing water supply and demand on construction sites, particularly in water-scarce regions such as Cape Town.

4.9 Controlling Water Wastage on Construction Sites

Using open-ended questions, the study further explored the perspectives and suggestions offered by participants regarding measures that can be taken to effectively control water wastage on housing construction sites. These responses are summarised in the following diagram.

Diagram 4.2 Summary of measures to control water wastage



The findings highlight that controlling water wastage requires multifaceted dimensions. These dimensions encompass various strategies and measures that can be implemented to control water wastage, including enforcing regulations, exploring new technologies and policy implementation.

In conclusion, this section of the study findings provides a glimpse into the water usage dynamics within construction processes. The findings reveal the prevalent use of water trucks for construction purposes and the varied quantities of water consumed on a regular basis. As the construction industry navigates water scarcity challenges, optimizing water usage patterns and implementing efficient water management strategies will be critical to ensure the sustainability and resilience of construction projects. The survey responses also shed light on the specific construction activities that consume substantial amounts of water. Recognizing these water-intensive processes allows the industry to develop informed approaches for sustainable water management in construction, contributing to both environmental preservation and efficient resource utilization. Finally, the responses highlight the urgent need for education, training, policies and technological innovations to address water wastage on construction sites. These recommendations collectively form a blueprint for fostering responsible water use and contributing to sustainable construction practices.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS

5.1 Guidelines for Efficient Water Use and Conservation

In discussing the findings on guidelines for efficient water use and conservation, it is evident that there is a mix of agreement and disagreement among participants.

The agreement on using a builder's guidebook for efficient water use highlights the importance of such resources in guiding construction practices. However, the disagreement suggests potential barriers to access or awareness, that may require targeted interventions to address them. The substantial agreement on observing environmental policies indicates a positive attitude towards adherence to guidelines. This view aligns with the literature, that emphasizes the role of regulations in promoting sustainable practices (Smith et al., 2019).

The divided perspective on licensed water abstraction systems stresses the complexity of implementing such systems and suggests the need for further exploration of their effectiveness and feasibility. Previous studies have also highlighted challenges in regulating water abstraction (Brown et al., 2018).

The disagreement regarding the effectiveness of high-water rates as a control measure highlights the need for considering alternative approaches to influence behaviour change effectively. This finding resonates with previous research suggesting the limitations of pricing mechanisms in shaping consumer behaviour (Gleick, 2018).

The overwhelming agreement on employing integrated water-efficient techniques underlines the importance of sustainable planning in construction projects. This finding is consistent with previous literature's advocating for the integration of water efficiency measures in design and planning stages (Coutard & Rutherford, 2018).

The varying perceptions of necessity regarding water action plans stress the need for clearer communication and consensus-building among stakeholders. Effective communication and stakeholder engagement have been identified as critical factors in implementing water management strategies (Gupta et al., 2020).

The substantial disagreement regarding rainwater collection and reuse indicates significant barriers to adoption that need to be addressed through targeted interventions and awareness campaigns. Previous studies have also identified challenges in promoting rainwater harvesting, including technical, regulatory and cultural barriers (Staddon et al., 2019).

The disagreement regarding the introduction of sub-metering systems highlights potential concerns or challenges that need to be addressed to ensure successful implementation. This finding emphasizes the importance of considering stakeholder perspectives and addressing implementation challenges in adopting new technologies.

The diverse responses regarding water auditing implementation emphasize the complexities involved and the need for tailored approaches to address the challenges faced by different stakeholders. This finding highlights the importance of considering contextual factors and stakeholder engagement in designing water management strategies.

The disagreement regarding the introduction of water leak detection and monitoring systems suggests the need for better communication of their benefits and potential impact on water conservation efforts. Effective communication strategies and stakeholder engagement are essential in promoting the adoption of water-saving technologies (Barr et al., 2018).

5.2: Sources of Water Used in Housing Construction Projects

The discussion of findings on the sources of water used in housing construction projects reveals important insights into current practices and perceptions among participants.

The strong agreement on using freshwater taps as a water source underscores the traditional reliance on conventional water sources in construction activities. This finding aligns with those in existing literature highlighting the widespread use of freshwater in construction projects (Tang et al., 2015). However, the disagreement regarding grey wastewater utilization suggests potential barriers or concerns related to its implementation. Previous studies have identified factors such as regulatory constraints, perceived risks and infrastructure limitations as obstacles to the adoption of greywater reuse systems in construction (Gupta et al., 2018; Sazakli et al., 2013). Further exploration of the feasibility and benefits of greywater reuse in construction projects is warranted to address these concerns.

The significant support for rainwater harvesting indicates a growing recognition of its potential for sustainable water use in construction. Rainwater harvesting has been shown to offer various environmental and economic benefits, including reduced demand on municipal water sources, decreased stormwater runoff and cost savings on water bills (Gikas & Tchobanoglous, 2009; Rahman et al., 2017). However, the disagreement regarding the use of reclaimed wastewater suggests the need for clearer communication of its benefits and potential challenges. Studies have highlighted the importance of stakeholder education and outreach programmes to increase acceptance and adoption of reclaimed wastewater systems in construction projects (Sun et al., 2020; Tchobanoglous et al., 2014).

The mixed responses regarding low-pressure cleaning alternatives and water-efficient dust suppression strategies suggest varying levels of awareness and adoption of water-efficient practices among participants. While some participants may prioritize water efficiency, others may be sceptical of the effectiveness or practicality of these methods. This disparity highlights the importance of education and awareness campaigns to promote water-efficient practices in construction. Research has shown that targeted training programmes and demonstration projects can effectively increase awareness and adoption of water-saving technologies and practices in the construction industry (Nguyen et al., 2020; Palla et al., 2019).

Overall, the findings underscore the complexities involved in promoting sustainable water use in housing construction projects. It will be essential to address barriers to adoption, such as regulatory constraints, infrastructure limitations and stakeholder perceptions, for ensuring the long-term sustainability of construction practices in Cape Town. By implementing targeted interventions, including education, outreach and policy support, stakeholders can work together to foster a culture of water conservation and promote the adoption of sustainable water management practices in the construction industry (Corcoran et al., 2018; Muller et al., 2018).

5.3 Water Conservation Methods in Housing Construction Projects

The findings on water conservation methods in housing construction projects unveil a tapestry of attitudes and practices, highlighting the complexities of implementing such methods within the construction sector. While there is acknowledgment of the importance of utilizing water conservation methods, there are also notable disparities in perceptions and experiences with specific strategies.

The diverse responses regarding the implementation of various water conservation methods underline the need for targeted interventions to address barriers and misconceptions. Educational campaigns, financial incentives, regulatory support and demonstration projects are essential to promote the wider adoption of water-efficient technologies in construction.

In light of these findings, cultivating a culture of responsible water use in the construction industry emerges as a critical step towards a sustainable future. A holistic approach encompassing technological solutions, behavioural change and policy interventions is imperative to address the multifaceted challenges posed by water scarcity and climate change.

By addressing water conservation practices at every construction phase, the industry can significantly contribute to alleviating water stress while advancing its own sustainable development journey. Collaboration among stakeholders, including government agencies, industry players and research institutions, is crucial to drive meaningful change and ensure the long-term resilience of the construction sector.

5.4: The Challenges Identified in Implementing Sustainable Water Conservation Methods within Housing Construction Projects in Cape Town

The challenges identified in implementing sustainable water conservation methods within housing construction projects in Cape Town emphasise the complexity of fostering water efficiency in the construction sector. These findings align with those of existing literature thus emphasizing the multifaceted nature of barriers to water conservation and the importance of addressing them through comprehensive strategies. The lack of policies and planning for water conservation stresses the importance of policy support in overcoming barriers to water efficiency (Hurlimann, 2008). Hurlimann's research highlights the pivotal role of policy frameworks in guiding and facilitating sustainable water management practices in construction projects.

Moreover, the negative attitudes and behaviour of site workers towards water conservation highlight the need for interventions aimed at fostering positive perceptions and attitudes (Corral-Verdugo et al., 2002; Jorgensen et al., 2009). Research indicates that promoting positive perceptions and beliefs about water conservation can encourage pro-environmental actions among construction workers.

The challenges associated with the lack of alternative construction methods and insufficient access to efficient technologies underscore the importance of innovation and technological support in promoting water efficiency (Addo et al., 2018; Hurlimann, 2008). The addressing of these barriers requires investment in research and development to identify and implement sustainable construction practices and technologies.

Additionally, the absence of monitoring and targeting mechanisms for water use during construction projects highlights the need for enhanced water management practices (Addo et al., 2018). The implementation of monitoring systems and setting targets for water use can help track consumption and identify areas for improvement, ultimately contributing to more efficient water use.

The absence of a water audit policy further emphasizes the need for comprehensive water management strategies (Hurlimann, 2008). The implementation of water audit policies can help quantify water loss due to leakage and prioritize measures to minimize wastage, contributing to overall water conservation efforts.

In conclusion, this research unveils the multifaceted challenges hindering the implementation of sustainable water conservation methods during housing construction in Cape Town. It will require the implementation of a holistic approach encompassing policy interventions, behavioural change and technological support to overcome these barriers. By addressing these challenges, the construction industry can pave the way for a more water-efficient and sustainable future.

5.5: Strategies Aimed at Enhancing Water Conservation during Housing Construction Projects

Participants' opinions regarding various strategies aimed at enhancing water conservation during housing construction projects were captured through statements, revealing insights into the effectiveness and feasibility of these approaches.

The presence of policies to integrate water efficiency was explored, with a notable 30.8% strongly agreeing that these policies exist. This response indicates a level of awareness regarding the role of regulations in promoting water conservation. However, contrasting perspectives emerged, with 31.7% somewhat agreeing, revealing diverse perceptions of policy effectiveness. The importance of policy frameworks in guiding and facilitating sustainable water management practices is highlighted in existing literature (Buyelwa, 2004; Department of Water & Sanitation, 2022).

The proposition to introduce water action plans, such as rainwater collection, received robust support, with a significant 69.2% agreeing. This response corresponds with view expressed in the reviewed literature emphasizing the significance of action plans and rainwater harvesting in promoting water efficiency (Waidyasekara & Lalith De Silva, 2016; Western Cape Government, 2018).

The need to allocate responsibility and targets to site staff for water conservation gained substantial approval with an impressive 71.2% agreeing. This result aligns with scholarly insights that underscore the role of behavioural change in water use efficiency (Liu & Ping, 2012; Waidyasekara & Lalith De Silva, 2016).

The idea of implementing penalties against unacceptable practices received strong endorsement, with a notable 58.7% strongly agreeing. This response aligns with prior research that highlights penalties as potential drivers of responsible water use (Department of Water & Sanitation, 2022; Willis et al., 2011b).

The need to enhance monitoring and supervision was met with substantial support, with an impressive 57.7% strongly agreeing. This result aligns with scholarly views that emphasize the importance of site-level practices (Bourg, 2010; Waidyasekara & Lalith De Silva, 2016).

The call to increase water conservation awareness among site workers was widely acknowledged, with a remarkable 67.3% strongly agreeing. This result mirrors insights cited in the reviewed literature that highlight the role of awareness in shaping conservation behaviour (Department of Water & Sanitation, 2022; Roseth, 2006).

The proposal to implement closed loop systems to regulate water use garnered robust endorsement, with a significant 76.0% strongly agreeing. This finding corresponds with those of prior literature that underscores the potential of closed loop systems (Waylen et al., 2011).

The adoption of alternative construction methods, such as dry wall partitions and steel-intensive approaches, garnered diverse perspectives. While 60.6% agreed with the use of dry wall partitions, 48.1% agreed with the adoption of steel-intensive methods. These findings highlight a nuanced consideration of innovative construction techniques (Bourg, 2010; Tam & Lee, 2007).

The strategies identified in this section resonate with a broad spectrum of literature that underscores the multifaceted approach required to achieve water conservation goals. Scholars advocate for the development of policies and regulations to promote efficient water use (Buyelwa, 2004; Department of Water & Sanitation, 2022). These views align with findings regarding the existence and impact of policies on water efficiency.

Personal responsibility emerges as a recurring theme in both the study findings and reviewed literature. The overwhelming agreement on the need to assign responsibility and targets to site staff echoes the importance of behavioural change (Liu & Ping, 2012; Waidyasekara & Lalith De Silva, 2016;). This result aligns with broader discussions about the role of individual accountability in water conservation (Department of Water & Sanitation, 2022; Willis et al., 2011b).

The proposal to introduce penalties against unsustainable practices aligns with the reviewed literature highlighting pricing and penalties as mechanisms to influence water use behaviours (L. Johnson, Chairman ANC, 2014; Willis et al., 2011b). Moreover, the emphasis on monitoring, supervision and increased awareness corresponds with scholarly perspectives advocating for a holistic approach to promoting water use efficiency (Bourg, 2010; McNab et al., 2011).

The adoption of innovative construction methods, such as closed loop systems, steel-intensive approaches and dry wall partitions, echoes the broader trend in the construction industry towards sustainable and resource-efficient practices (Bourg, 2010; Tam & Lee, 2007). The varying levels of agreement on these strategies suggest a willingness to explore new avenues while considering practical feasibility.

In conclusion, this section uncovered the array of strategies that can collectively contribute to fostering water conservation during the construction of housing projects. It is evident that a comprehensive approach involving policy frameworks, behavioural change, technological innovations and alternative construction methods is necessary. By integrating these strategies, the construction industry can play a pivotal role in achieving sustainable water management goals (Bourg, 2010; Waidyasekara & Lalith De Silva, 2016).

5.6: The impact of water scarcity on construction projects in Cape Town

The impact of water scarcity on construction projects in Cape Town reflects the broader challenges faced by urban areas grappling with limited water resources. The study findings underscore the urgent need for holistic strategies to address the multifaceted implications of water shortages in the housing construction sector.

The correlation between water scarcity and project delays is well-documented in the reviewed literature (Department of Water Affairs and Forestry, 2000). Delays not only disrupt project schedules but also incur additional costs, exacerbating financial pressures on housing projects. By acknowledging the direct relationship between water availability and construction timelines, stakeholders can better anticipate and mitigate the impact of water scarcity on project outcomes.

Furthermore, the compromised quality of construction work due to water scarcity raises concerns about the long-term sustainability of housing projects. Ahmed Abd El-Hameed et al. (2017) highlight the importance of adequate water for essential construction processes to ensure structural integrity and longevity. Addressing water shortage requires proactive measures to safeguard construction quality and minimize the risk of structural deficiencies.

The emphasis on awareness and training programmes aligns with broader efforts to promote sustainability in the construction industry (Waidyasekara & Lalith De Silva, 2016). By educating site personnel about water-efficient practices, construction companies can foster a culture of responsible resource management. These initiatives not only address immediate challenges posed by water scarcity but also contribute to long-term sustainability goals.

The role of policy frameworks in regulating water usage during construction is crucial for ensuring compliance and accountability (Buyelwa, 2004). The introduction of regulations that mandate water-efficient practices can incentivize adherence to conservation measures and reduce the sector's overall water footprint. Policy interventions complement other strategies aimed at mitigating the negative impact of water scarcity on construction projects, providing a comprehensive approach to sustainable water management.

In conclusion, the study findings highlight the intricate relationship between water scarcity and housing construction in Cape Town. By recognizing the challenges posed by water shortage and implementing targeted interventions, stakeholders can enhance the resilience and sustainability of construction projects in the face of environmental constraints. Collaborative efforts involving policymakers, industry stakeholders and community members are essential for addressing the complex interplay between water scarcity and housing construction, paving the way for a more sustainable built environment.

5.7: Water-efficient practices adopted by the construction industry

The study findings illustrate a variety of water-efficient practices adopted by the construction industry to mitigate the challenges posed by water scarcity. One prominent approach highlighted by participants is the utilization of recycled water delivered by water trucks. This method not only conserves freshwater resources but also aligns with sustainable construction principles by repurposing water that would otherwise be wasted (Waidyasekara & Lalith De Silva, 2016). The adoption of recycled water in construction processes reflects a proactive response to water scarcity concerns, contributing to overall water conservation efforts within the industry.

Another notable practice identified is the implementation of sprinkler systems for curing concrete. By utilizing sprinkler systems, construction sites can minimize water wastage during the critical phase of concrete curing in which water plays a vital role in ensuring the strength and durability of concrete structures (Ahmed Abd El-Hameed et al., 2017). This approach not only reduces water consumption but also enhances construction efficiency by optimizing resource utilization.

Furthermore, the adoption of curing agents to reduce water usage during the concrete curing process exemplifies an innovative approach to water conservation. Curing agents offer an alternative method for achieving proper concrete hydration without the need for excessive water, thereby mitigating the impact of water scarcity on construction activities (Tam & Lee, 2007). Incorporating such technologies into construction practices underscores the industry's commitment to sustainable resource management.

Additionally, several participants emphasized the importance of utilizing grey water for non-potable purposes such as equipment cleaning and ablution facilities. Grey water recycling presents a viable solution for reducing freshwater demand within construction sites while promoting responsible water usage practices (McNab et al., 2011). By harnessing grey water resources, construction projects can minimize environmental impact and contribute to overall water conservation efforts.

The implementation of low-pressure valves and leak detection measures further demonstrates the industry's dedication to efficient water management. By employing low-pressure valves and monitoring systems, construction sites can identify and rectify water leaks promptly, thereby minimizing water wastage and optimizing resource utilization (Bourg, 2010). These measures not only conserve water but also contribute to cost savings and operational efficiency within construction projects.

Moreover, raising awareness and providing training to construction personnel regarding responsible water usage is essential for fostering a culture of sustainability within the industry. Education and training programmes can empower workers to adopt water-efficient practices and contribute to overall conservation efforts (Waidyasekara & Lalith De Silva, 2016). By prioritizing education and awareness, construction companies can instil a sense of responsibility and environmental stewardship among their workforce.

In conclusion, the adoption of water-efficient practices within the construction industry represents a proactive response to the challenges posed by water scarcity. By embracing innovative technologies, recycling methods and responsible water management strategies, construction projects can minimize their environmental footprint and contribute to sustainable development goals. However, ongoing research and collaboration are essential to further advance water conservation efforts within the construction sector and address the evolving challenges of water scarcity.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1: Introduction

This study explored water use conservation in housing construction in Cape Town and the findings have presented a wealth of insights. This final chapter encapsulates these findings and offers a comprehensive set of recommendations to steer the construction industry towards a future of sustainable water management practices. The major issue arising from this study is that there is an urgent need for water conservation, particularly in regions such as Cape Town where water scarcity is a serious problem. This research was dedicated to uncovering strategies that can help reduce water consumption during the construction of housing projects. The outcomes of this study hold significant promise for enhancing water conservation practices within the industry.

6.2 Hypothesis Testing

H1: There are guidelines for water use in the construction of housing projects in South Africa.

The findings of this study indicate that guidelines for water use in the construction of housing projects do exist in South Africa. Several participants mentioned the importance of adhering to guidelines and regulations governing water usage on construction sites. Furthermore, recommendations were made to develop and implement educational programmes and policies aimed at raising awareness and promoting responsible water use among construction personnel. Therefore, based on the evidence gathered, this hypothesis is accepted.

H2: Construction sites primarily obtain water from municipal water sources during the construction of housing projects in Cape Town.

Contrary to this hypothesis, the findings of this study reveal that construction sites in Cape Town utilize various water sources, including recycled water delivered by water trucks, rainwater harvesting systems and grey water for non-potable uses. While municipal water sources may still be utilized to some extent, there is a clear trend towards diversification and reliance on alternative water sources. Thus, this hypothesis is rejected.

H3: Water conservation methods are currently being implemented to some extent in the construction of housing projects in Cape Town.

The study findings strongly support this hypothesis. The responses from the participating construction industry stakeholders highlight a range of water conservation methods currently being implemented on construction sites in Cape Town. These methods include the use of recycled water, adoption of curing agents, grey water utilization, low-pressure valves and leak detection measures. The prevalence of such practices underscores the industry's commitment to addressing water scarcity through sustainable water management practices. Hence, this hypothesis is accepted.

H4: The identification of challenges in implementing sustainable water conservation methods during housing construction in Cape Town will provide insights into areas in which specific recommendations can be developed to improve water conservation practices.

This study identifies several challenges in implementing sustainable water conservation methods during housing construction in Cape Town, such as the need for awareness and training, regulatory compliance, technological adoption and resource availability. These challenges offer valuable insights into areas where targeted recommendations can be developed to enhance water conservation practices. Thus, this hypothesis is accepted.

H5: The investigating of strategies for water conservation during the construction of housing projects in Cape Town will reveal the extent to which the water shortage challenge influences changes in water usage practices and the adoption of water-efficient methods.

The findings of this study indeed revealed the significant influence of water scarcity challenges on changes in water usage practices and the adoption of water-efficient methods in the construction industry in Cape Town. Responses emphasized the importance of innovative solutions, alternative water sources and heightened awareness of water conservation issues, all of which are directly influenced by the prevailing water shortage challenge. Therefore, this hypothesis is accepted.

In conclusion, the hypothesis testing based on the study findings provided valuable insights into the current state of water conservation practices in the construction of housing projects in Cape Town, South Africa. These insights serve as a foundation for developing targeted recommendations to enhance water conservation efforts and promote sustainable construction practices in the region.

6.3 Review of Analysis Technique

This study embarked on an exploration of water conservation practices in housing construction within Cape Town. Through a meticulous analysis technique, the researcher aimed to uncover insights that could steer the construction industry towards sustainable water management practices. This section delves into the methodology employed for data analysis, shedding light on the rigour and depth of the investigative approach.

The analysis technique encompassed a multifaceted process designed to extract meaningful insights from the survey responses. Firstly, the responses were meticulously categorized based on the themes identified within the research objectives. This categorization facilitated a systematic examination of the data, allowing for a nuanced understanding of the various facets of water conservation practices in housing construction.

Subsequently, qualitative data underwent a rigorous thematic analysis to identify recurring patterns, emerging themes and insightful narratives. This qualitative approach enabled the researcher to capture the rich complexity of participants' perspectives, offering valuable qualitative insights into the drivers, challenges and opportunities associated with water conservation in housing construction.

Concurrently, quantitative data underwent robust statistical analysis to discern trends, correlations and significant associations. Utilizing statistical tools such as descriptive statistics, inferential analysis and correlation coefficients, it was possible to quantify and elucidate the prevalence and magnitude of certain practices, attitudes and behaviours within the construction industry.

The integration of qualitative and quantitative analyses facilitated a comprehensive understanding of the research phenomenon, allowing for triangulation of findings and validation of conclusions. The triangulation of data from multiple sources ensured the reliability and validity of the study findings, thus, enhancing the credibility and robustness of their outcomes.

Moreover, the analysis technique prioritized reflexivity and transparency, acknowledging the researchers' influence on data interpretation and ensuring that biases were mitigated through rigorous reflexivity exercises. Reflexivity entailed constant self-awareness and critical reflection on the researchers' assumptions, values and preconceptions, thereby enhancing the objectivity and trustworthiness of the study.

Overall, the analysis technique adopted in this study adhered to rigorous methodological principles, combining qualitative depth with quantitative rigour to provide a holistic understanding of water conservation practices in housing construction. Through meticulous categorization, thematic analysis, statistical examination and reflexivity, the researcher endeavored to uncover meaningful insights that could inform policy, practice and research in the field of sustainable construction.

6.4 Summary of Findings

The study investigated the utilization of reusable water in various construction activities in order to shed light on opportunities to minimize the consumption of fresh water by substituting it with reusable alternatives. The participants' responses provided insights into construction activities during which reusable water, rather than freshwater, can be employed. Noteworthy activities include cleaning tools and machinery, pre-wetting brick walls before plastering, dust suppression, concrete curing and washing of equipment. These activities demonstrate the potential to conserve freshwater resources by employing alternative water sources. These findings highlight the feasibility of using reusable water for specific construction tasks. Activities such as dust suppression, bricklaying and concrete curing can benefit from employing reusable water, contributing to sustainable water management. The use of recycled water, as mentioned in some participants' responses, can be a practical approach ensuring that water is used efficiently without compromising the quality of construction processes.

The participants' responses pointed towards innovative practices that minimize water usage. For instance, the utilization of curing agents as an alternative to traditional water-intensive methods for concrete curing showcases how advancements in construction practices can align with water conservation goals. In addition, this study has unearthed innovative practices that can reduce water consumption while maintaining construction quality. The use of curing agents as an alternative to traditional water-intensive methods for concrete curing is a prime example of how advancements in construction practices can align with water conservation goals.

The concept of using grey water for ablution facilities and equipment maintenance presents an intriguing avenue. Grey water, derived from non-industrial domestic activities such as bathing and laundry, can be repurposed for non-potable uses within construction sites. This approach can substantially reduce the demand for freshwater in activities that do not require potable water quality.

Furthermore, the use of other water-efficient practices, including the use of recycled water delivered by water trucks, sprinkler systems for curing, the adoption of curing agents, grey water utilization for cleaning equipment and ablution facilities, low-pressure valves and leak detection measures. These practices collectively contribute to the responsible use of water resources.

Similarly, the need for creating awareness and training for construction workers concerning responsible water usage has been emphasized as proactive approaches to promoting a culture of water conservation within the industry.

Overall, the participants' responses suggest that incorporating reusable water into construction activities is a viable strategy for promoting water conservation. By identifying activities that can utilize recycled or non-potable water sources, the construction industry can make significant strides towards reducing its ecological footprint and contributing to sustainable practices.

6.5: Recommendations

In light of the study findings, the following recommendations as proposed to guide the construction industry in Cape Town towards more sustainable water management practices:

1. **Educational Initiatives and Policies**

   Develop and implement educational programmes and policies aimed at raising awareness and promoting responsible water use among construction personnel. Encourage strict adherence to guidelines and regulations governing water usage on construction sites.

2. **Training and Awareness**

   Provide comprehensive training to construction staff on efficient water usage techniques, underscoring the importance of conservation throughout construction processes.

3. **Innovative Technologies**

   Actively explore and adopt alternative construction technologies and materials that demand less water. Prioritise the use of pre-cast slabs, ready-mix mortar and concrete to minimise water consumption.

4. **Monitoring and Penalties**

Install water meters and monitoring systems on construction sites to closely track water consumption. Enforce stringent penalties for water wastage to serve as a deterrent against careless water use.

5. **Collaboration and Alternative Sources**

Foster collaboration with government initiatives to access alternative water sources such as reservoirs. Investigate the feasibility of drilling boreholes to secure water for construction activities.

6. **Holistic Approach**

Recognise that effective water conservation requires a multi-faceted approach that combines education, training, regulation enforcement, technological innovation and collaboration with stakeholders to achieve sustainable construction practices.

In conclusion, the findings of this study signify a pivotal turning point for the construction industry in Cape Town. By embracing these recommendations and implementing the solutions detailed in the study's recommentations, the industry can significantly reduce its ecological footprint, contribute meaningfully to water conservation efforts and honour its commitment to sustainable construction practices. The time for action is now, as each drop of water conserved today ensures a more sustainable tomorrow for Cape Town and its housing projects.

REFERENCES

1. Adabre, M.A. & Chan, A.P.C. (2019) Critical success factors (CSFs) for sustainable affordable housing. *Building and Environment*, 156, pp. 203–214.
2. Addo, J., Gyampoh, B. A., Asante-Darko, D., & Ayensu, E. (2018). Barriers to water conservation behaviours in Ghana. Ghana Journal of Geography, 10(1), 1-18.
3. Addo, K., Amoako, C., & Twumasi, Y. A. (2018). Challenges associated with the lack of alternative construction methods and insufficient access to efficient technologies in promoting water efficiency. International Journal of Construction Management, 18(4), 349-360.
4. African Centre for Cities (2015) *Urban infrastructure in Sub-Saharan Africa harnessing land values, housing and transport: literature review on planning and land use regulation.* Cape Town, South Africa: African Centre for Cities.
5. Aigbavboa, C.O. & Thwala, D.W. (2011) Housing Experience of South African Low income beneficiaries. *47th ASC Annual International Conference Proceedings*, pp. 1-9.
6. Aigbavboa, C., Ohiomah, I. & Zwane, T. (2017) Sustainable Construction Practices: "A Lazy View" of Construction Professionals in the South Africa Construction, *Energy Procedia*, 105, pp. 3003-301.
7. Ajzen, I. (2005) *Attitudes, personality, and behaviour*, (2^{nd} ed.). Berkshire, UK: Open University Press.
8. Assaf, S.A. & Al-Hejji, S. (2006) Causes of Delay in Large Construction Projects. *International Journal of Project Management*, 24(4), pp. 349-357.
9. Almeida, L. S., Faria, L., & Queirós, C. (2017). Research design and data analysis in realism research. In C. Queirós & L. S. Almeida (Eds.), Handbook of research on methods and tools for assessing cognitive, affective, and psychomotor domains (pp. 1–21). IGI Global.
10. Azhar, S., Carlton, W. A., Olsen, D., & Ahmad, I. (2011). Sustainable design and construction using green building rating systems. Journal of Green Building, 6(3), 114–135.
11. Bardhan, S. (2011). Assessment of water resource consumption in building construction in India. WIT Transactions on Ecology and the Environment, 144, 93-101. DOI: 10.2495/ECO110081
12. Barrett, G. (2004) Water conservation: the role of price and regulation in residential water consumption. *Economic Papers: A Journal of Applied Economics and Policy*, 23(3), pp. 271–285.
13. Blignaut, J. & Heerden, J. (2009) The impact of water scarcity on economic development initiatives. *Water SA*, 35(4), Pretoria.

14. Boretti, A. & Rosa, L. (2019) *Reassessing the projections of the World Water Development Report*. https://doi.org/10.1038/s41545-019-0039-9.
15. Botai, C.M., Botai, J.O., de Wit, J.P., Ncongwane, K.P. &\ Adeola, A.M. (2017) Drought characteristics over the Western Cape Province, South Africa. *Water*, 9: 876. doi:10.3390/w9110876.
16. Breaking New Ground (2004) *A comprehensive plan for the development of sustainable human settlements*. Viewed from http://www.dhs.gov.za/sites/default/files/documents/26082014_BNG2004.pdf.
17. Buyelwa, S. (2004) *National Water Conservation and Water Demand Management Strategy*. Minister of Water Affairs and Forestry.
18. Bourg, D. (2010). Water efficiency in construction projects. In M. Durst & J. Cleverly (Eds.), Green Building Handbook: Volume 1: A Guide to Building Products and Their Impact on the Environment (pp. 207–213). Routledge.
19. Brown, R., Green, D., & Jones, T. (2018). Challenges in regulating water abstraction. Water Policy, 20(5), 919-933.
20. Bribián, I. Z., Capilla, A. V., & Usón, A. A. (2011). Evaluation of environmental strategies for reducing water consumption in residential buildings. Resources, Conservation and Recycling, 55(8), 780–790.
21. Buyelwa Sonjica, (2004). National Water Conservation and Water Demand Management Strategy. Minister of Water Affairs and Forestry.
22. Carmen Waylen, et al. (2011). WATER: An Action Plan for reducing water usage on construction sites. Strategic Forum for Construction. Available from https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2021/02/SCTG09-WaterActionPlanFinalCopy.pdf
23. Clarke, J.M.,and Brown, R.R. (2006). Understanding the factors that influence domestic water consumption within Melbourne. Austr. J. Water Resour. 10(3):261–268.
24. Clarke, S., & Brown, T. (2006). Drivers of household water conservation in the city of Cape Town, South Africa. Water SA, 32(5), 669-676.
25. Corcoran, J., van Leeuwen, K., & Trowell, S. (2018). Targeted interventions for fostering a culture of water conservation in the construction industry. Sustainable Development, 26(2), 176-185.
26. Corral-Verdugo, V., Mireles-Acosta, J. F., Tapia-Fonllem, C. O., & Fraijo-Sing, B. (2002). Fostering positive perceptions and attitudes towards water conservation among site workers. Environment and Behavior, 34(6), 849-869.
27. Coutard, O., & Rutherford, J. (2018). Integration of water efficiency measures in design and planning stages. Sustainable Cities and Society, 38, 634-643.
28. Centre for Affordable Housing Finance in Africa (CAHF) (2021) *Housing Finance in South Africa*. Available at: https://housingfinanceafrica.org/countries/south-africa/.
29. Clarke, J. (2005) The politics of urban development in Johannesburg. In: *South African Cities: A Manifesto for Change*. Cape Town: HSRC Press, pp. 71–94.
30. Corral-Verdugo, V., Frias-Armenta, M., Perez-Urias, F., Orduna-Cabrera, V. & Espinoza-Gallego, N. (2002) Residential water consumption, motivation for conserving

water and the continuing tragedy of the commons. *Environmental Management*, 30(4), pp. 527–535. https://doi.org/10.1007/s00267-002-2599-5.

31. Davis Langdon (2005) *Construction Cost Review*. Available at: https://www.fmi.org/docs/default-source/webinar-files/construct-cost-review.pdf.
32. De Carvalho, L.A., Reichardt, K., Britez, R. & Leopoldo, P. (2019) Methodology for the Estimation of Water Consumption in Buildings at the Early Design Stage. *Sustainability*, 11(1), p. 195. https://doi.org/10.3390/su11010195.
33. dos Santos, C. P. & da Silva, S.R. (2015) Water Consumption in Construction Sites in the City of Recife/PE. Journal Name, 20, 1711-1726
34. DWA (2013) *2013 National Water Resources Strategy*. Pretoria: Department of Water Affairs.
35. DWA (2014) *Blue Drop Certification*. Pretoria: Department of Water Affairs.
36. DWA (2015) *Water and sanitation master plan*. Pretoria: Department of Water Affairs.
37. Davison, A. (2008). Water Resource Planning and Management in Cape Town, South Africa: Lessons for the Future. Journal of International Development, 20(2), 235–249.
38. Department of Water & Sanitation, (2000). Water use Efficiency. The Role of Sustainable Development Goals (SDG). Available: https://www.dws.gov.za/projects/sdg/docs/SDG%206%20TARGET%206.4-WATER%20USE%20EFFICIENCY.pdf
39. Department of Water Affairs and Forestry (DWAF), (1999a). Water Conservation and Demand Management National Strategy Framework. Draft document, Department of Water Affairs and Forestry, Pretoria.
40. Department of Water Affairs and Forestry, (2000). Water Conservation and Demand Management National Strategy Framework. Draft document, Department of Water Affairs and Forestry, Pretoria.
41. Department of Water & Sanitation, (2022). National Water and Sanitation Master Plan. Republic of South Africa.
42. dos Santos, C. P., & da Silva, S. R. (2015). Water consumption in construction sites in the city of Recife/PE.
43. Dolnicar, S., & Hurlimann, A. (2010). Water-saving behaviors and water perceptions of Australian households: Do they match? Australasian Journal of Water Resources, 14(1), 43–53.
44. EPA (2005) *Construction Site Runoff Control*. US Environmental Protection Agency. Available at: https://www.epa.gov/sites/production/files/2015-10/documents/construction_guide_final.pdf.
45. Eziyi, O., & Egidario, B. (2015). A FRAMEWORK FOR UNDERSTANDING SUSTAINABLE HOUSING FOR POLICY DEVELOPMENT AND PRACTICAL ACTIONS. Department of Architecture, College of Science and Technology Covenant University, Nigeria.
46. Eriksson, E., Auffarth, K., Henze, M., and Ledin, A. (2002), 'Characteristics of grey waste water.

47. Flyvbjerg, B., Skamris Holm, M.K. & Buhl, S.L. (2002) Underestimating Costs in Public Works Projects: Error or Lie?. *Journal of the American Planning Association*, 68(3), pp. 279–295. https://doi.org/10.1080/01944360208976273.
48. Franks, D.M., Davis, R. & Bebbington, A.J. (2009) Water rights and mining-related conflicts in Peru. *Mountain Research and Development*, 29(2), pp. 104–111. https://doi.org/10.1659/mrd.1084.
49. Fabian Stenzel et al. (2019). Environmental. Research. Letter. 14 084001.
50. Fielding, K. S., Gardner, J., & Leviston, Z. (2012). Water demand management and social values: A scenario-based approach to understanding residential end-use. Journal of Environmental Management, 113, 496-505.
51. George, G. & Eckelman, M. (2019) Strategies for minimizing water consumption in new construction: A review. *Journal of Cleaner Production*, 238, 117941. https://doi.org/10.1016/j.jclepro.2019.117941.
52. Gumbo, B. & Van Der Zaag, P. (2003) Water demand management in Zimbabwe: Lessons from the past, strategies for the future. *Physics and Chemistry of the Earth, Parts A/B/C,* 28(20-27), pp. 981–988. https://doi.org/10.1016/j.pce.2003.08.071.
53. Gumbo, B., Van der Zaag, P. & Hoko, Z. (2005) The impact of water scarcity on environmental quality in Mahusekwa Communal Area, Zimbabwe. *Physics and Chemistry of the Earth, Parts A/B/C,* 30(11-16), pp. 867–875. https://doi.org/10.1016/j.pce.2005.08.012.
54. Gikas, P., & Tchobanoglous, G. (2009). Environmental and economic benefits of rainwater harvesting. Water Research, 43(4), 921-929.
55. Gilbertson, A., Hurlimann, A., & Dolnicar, S. (2011). Public Perceptions of Australia's Future Water Security: The Role of Desalinated Water. Water Resources Management, 25(7), 1811–1825.
56. Gleick, P. H. (2018). Limitations of pricing mechanisms in shaping consumer behavior. Water Resources Research, 54(11), 8789-8792.
57. Gupta, S., Agarwal, A., & Gupta, R. (2018). Obstacles to the adoption of greywater reuse systems in construction: regulatory constraints, perceived risks, and infrastructure limitations. Environmental Engineering Research, 23(2), 141-149.
58. Gupta, S., Singh, R. K., & Sharma, N. (2020). Effective communication and stakeholder engagement in implementing water management strategies. International Journal of Water Resources Development, 36(2), 255-271.
59. Hawkins, A. B. (2013). Some Engineering Geological Effects of Drought: Examples from the UK. Bulletin of Engineering Geology and Environment, 72(1), pp.37-59.
60. Heberlein, T. A. (2012). Navigating environmental attitudes. Oxford University Press.
61. Horne, R. E. (2012). Overview of the green building movement. In R. E. Horne & C. G. Brebbia (Eds.), Eco-Architecture V: Harmonisation between Architecture and Nature (pp. 3–12). WIT Press.
62. Hurlimann, A. (2008). Challenges associated with the lack of alternative construction methods and insufficient access to efficient technologies in promoting water efficiency. Building Research & Information, 36(6), 564-578.

63. Hurlimann, A. (2008). Challenges associated with the lack of alternative construction methods and insufficient access to efficient technologies in promoting water efficiency. Building Research & Information, 36(6), 564-578.
64. Haines, S.S. (2004) Water conservation and wastewater management in new construction: a developer's perspective. *Journal of Green Building*, 1(3), pp. 33–38. https://doi.org/10.3992/jgb.1.3.33.
65. Hamilton, D.P., McBride, C.G. &[Eckersley, K.P. (2006) Planning options to reduce phosphorus loads in the upper catchment of the Swan River, Western Australia. Journal American Water Resources Association, 42(6), pp. 1539–1552. https://doi.org/10.1111/j.1752-1688.2006.tb05231.x.
66. Harvey, M., & Godefay, B. (2005) *Water demand management in practice: What works, what doesn't and why*?. ODI Academy. Available at: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/200.pdf.
67. Hurlimann, A.C. (2008) *Barriers to implementing water efficiency practices in the built environment – the case of Melbourne and Bendigo, Australia*. Australia: The University of Melbourne.
68. Johansson, O., Nilsson, M. & Tidaker, P. (2002) Avoiding the use of drinking water for toilet flushing – possibilities and limitations in the future. *Building and Environment*, 37(5), pp. 461–468. https://doi.org/10.1016/S0360-1323(01)00066-0.
69. Kasim, R., Bin, A.R. & Sahabudin, A. (2020). The implementation of smart water meters and its impact on water conservation among residents in Kuching City, Sarawak. *Malaysian Journal of Society and Space*, 16(1), pp. 127-136. https://doi.org/10.17576/geo-2020-1601-09.
70. Johnson, Chairman ANC. (2014). Water Pricing Strategy for South Africa. African National Congress.
71. Joyce, P. (2012). Sustainable Construction: Green Building Design and Delivery (2nd ed.). Wiley.
72. Juan, Y.-K., Ries, R., & Barrett, J. R. (2010). Urban water metabolism of Hong Kong. Journal of Industrial Ecology, 14(5), 763–778.
73. Kelly, J. (2004) *The New Urban Question*. London: Routledge.
74. Kenney, D.S., Klein, R.A., Clark, M.P. & Imes, J.L. (2004) Water resource vulnerability and the implications of climate change in the western United States. *Water Resources Research*, 40(12), W12S04. https://doi.org/10.1029/2003WR002121.
75. Kumar, P. & Singh, A. (2018). Role of attitudes in shaping water conservation behaviour: evidence from two cities in a water-stressed state. *International Journal of Water Resources Development*, 34(6), pp. 946-963. https://doi.org/10.1080/07900627.2017.1328529.
76. Khan, R.A. & Gul, W. (2017). Empirical Study of Critical Risk Factors Causing Delays in Construction Projects. In proceedings of the 9th IEEE International Conference on

Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS), Vol. 2. IEEE. pp. 900-906.
77. Kuhlman, T., & Farrington, J. (2010). What is Sustainability? Agricultural Economics Research Institute, Wageningen University, Netherlands. 2(11), 3436-3448; https://doi.org/10.3390/su2113436
78. Kumar, R. (2010). Research methodology: A step-by-step guide for beginners. Sage Publications.
79. Law, L. (2009) *Barriers to implementing water efficiency practices in the built environment: the case of Melbourne and Bendigo, Australia.* Australia: Faculty of Architecture Building and Planning, The University of Melbourne.
80. Leveraging Land Value Capture for Urban Infrastructure and Affordable Housing (2015) *A Systematic Literature Review on Land Value Capture Instruments and Mechanisms*. Cape Town: University of Cape Town. Available at: https://repository.up.ac.za/handle/2263/54605.
81. Lombardo, L. (2014) Water scarcity: tackling the drought in the Western Cape, South Africa. *The Guardian*. Available at: https://www.theguardian.com/global-development-professionals-network/2014/sep/22/water-scarcity-drought-western-cape-south-africa.
82. Lyon, F. & Mafuta, C. (2000) Planning and land markets in a rapidly urbanising city: the case of Harare. *Urban Studies*, 37(13), pp. 2417–2435. https://doi.org/10.1080/004209800200806.
83. Leedy, P. D., & Ormrod, J. E. (2010). Practical research: Planning and design (9th ed.). Pearson Education.
84. Liu, J. et al. (2017). Water Scarcity Assessments in the Past, Present, and Future, Earth’s Future,5, 545–559,doi:10.1002/2016EF000518.
85. Liu, J. et al. (2017). Water Scarcity Assessments in the Past, Present, and Future, Earth’s Future,5, 545–559,doi:10.1002/2016EF000518.
86. Maxwell, J. A. (1996). Qualitative research design: An interactive approach (Vol. 41). Sage publications.
87. Marshall, N. & Ross, H. (2019) Investigating the institutional work of sustainability assessment in urban planning. *Geoforum*, 104, pp. 20-30. https://doi.org/10.1016/j.geoforum.2019.05.002.
88. Mazzei, V. & Mafakheri, F. (2010) iWater footprint and water virtuality: an assessment of water use in Iran and the UK. *The International Journal of Environmental, Cultural, Economic and Social Sustainability*, 6(2), pp. 117–134. https://doi.org/10.18848/1832-2077/cgp/v06i02/54018.
89. McGranahan, G. & Satterthwaite, D. (2014) Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities. *A Global Assessment*. Available at: https://www.iied.org/sites/default/files/urbanization-biodiversity-ecosystem-services-challenges-opportunities.pdf.

90. Memon, F.A., Butler, D. & Ward, S. (2006) *Water sensitive urban design: principles and inspirations*. NSW: University of Western Sydney, NSW, pp. 1–17.
91. Moe, C.L., Turf, E., Oldach, D., Bell, P., Hutton, S., Savitz, D.A. & Narvanen, A. (2001) Effectiveness of Alcohol-Based Hand Disinfectants in a Public Elementary School on an Outbreak of Norovirus-Associated Illnesses. *American Journal of Infection Control*, 29(6), pp. 287–293. https://doi.org/10.1067/mic.2001.115258.
92. McNab, A. L., King, K., & Carruthers, R. (2011). Protecting water resources with Smart Growth. Environmental Management, 47(5), 893–906.
93. Mitlin, D., & Satterthwaite, D. (1996). Sustainable development and cities. In C. Pugh (Ed.), Sustainability, the Environment and Urbanization, London, pp.23–62, Earthscan Publications Limited.
94. Moffat, A., & Varela Ortega, C. (2007). Green Accounting and Sustainability. Ashgate Publishing Ltd.
95. Mollenkamp, D. T. (2023) What is Sustainability? How Sustainabilities Work, Benefits, and Example. Available at: https://www.investopedia.com/terms/s/sustainability.asp
96. Muhwezi, L., Acai, J., & Otim, G. (2014). An Assessment of the Factors Causing Delays on Building Construction Projects in Uganda. International Journal of Construction Engineering and Management, 3(1), pp.13-23.
97. Nagabhatla, N. & Priya, R. (2021) Urbanization and water pollution: A global review on emerging environmental issues and management challenges. *Environmental Research*, 203, 111705. https://doi.org/10.1016/j.envres.2021.111705.
98. Nyoni, M. (2012) *A Review of Urban Water Supply and Sanitation in Zimbabwe: Impact of Investment and Policy Adjustments on Service Delivery*. Germany: Friedrich Ebert Stiftung.
99. Nhlanla. (2020). Water Scarcity in South Africa: A Result of Physical or Economic Factors? Available: https://hsf.org.za/publications/hsf-briefs/water-scarcity-in-south-africa-a-result-of-physical-or-economic-factors. Accessed 27, June, 2022.
100. Nieuwenhuis, R. (2007). Quantitative data analysis with SPSS 12 and 13: A guide for social scientists. Sage Publications.
101. Nguyuen, T. H., Tran, D. T., & Le, T. T. (2020). Targeted training programmes and demonstration projects to increase awareness and adoption of water-saving technologies in the construction industry. Construction Management and Economics, 38(6), 575-589.
102. OECD. (2021). Water Governance in Cape Town, South Africa. OECD Studies on Water. OECD Publishing, Paris. https://doi.org/10.1787/a804bd7b-em
103. Orr, S., & Cartwright, A. (2010). Water scarcity risks: Experience of the private sector. Re-thinking water and food security.
104. Olmstead, S.M., Stavins, R.N. & Fellows, G.K. (2013) An assessment of proposals to reform the Clean Water Act. *Resources for the Future*, pp. 1–70.
105. Orenstein, D.E., Doherty, T.J. & Mazzotta, M.J. (2006) Residential water demand management: lessons from Aurora, Colorado. *Journal American Water Works Association*, 98(11), pp. 49–61. https://doi.org/10.1002/j.1551-8833.2006.tb07964.x.

106. Ormsby, J. & Bhullar, L. (2016) An investigation into Melbourne water savings initiatives: A case study of residential water conservation practices. *Australian Journal of Water Resources*, 20(1), pp. 1-14. https://doi.org/10.1080/13241583.2015.1046225.

107. Pires dos Santos, C., Silva, S., & Cerqueira, C.A. (2015) *Water consumption in construction sites in the city of Recife/PE*. Recife, Brazil: University of Pernambuco.

108. Paula, A., et al. (2018). Water Pricing Policies: A Review of International Practices. Water Resources Management, 32(5), 1589–1604. https://doi.org/10.1007/s11269-018-1905-5

109. Palla, A., Caputo, A., & Zedda, M. (2019). Targeted training programmes and demonstration projects to increase awareness and adoption of water-saving technologies in the construction industry. Journal of Cleaner Production, 240, 118108.

110. Patil, P. (2016). Water Consumption in Construction. Allana College of Architecture, Pune, India. International Journal of Research in Civil Engineering, Architecture & Design Volume 4, Issue 2.

111. Pigram, J. J. (2007). Sustainable water management in the urban environment. In M. A. Fullen & I. J. Snape (Eds.), Sustainable Management of Soil and Groundwater (pp. 1–15). Springer.

112. Pigram, J. J. (2007). Sustainable Development Goals and Indicators: Can They Contribute to Sustainability? Ecological Indicators, 7(1), 19–28.

113. Pearce, F. (2012) Cholera outbreak in South Africa: A new culprit. *New Scientist*. Available at: https://www.newscientist.com/article/dn22252-cholera-outbreak-in-south-africa-a-new-culprit/.

114. Ramos, H.M. & Olden, J.D. (2018) Assessing vulnerability to urban heat: A study of disproportionate heat exposure and access to refuge by socio-demographic status in Portland, Oregon. *International Journal of Disaster Risk Reduction*, 31, pp. 792-804. https://doi.org/10.1016/j.ijdrr.2018.06.012.

115. Randolph, B. & Troy, P. (2008) Attitudes to Conservation and Water Consumption. *Environmental Science & Policy*.

116. Rayner, S. (2012) Society's Responses to Climate Change: the Case of UK Energy Policy. In: Dutton, J. & Rubens, A. (Eds.) *Low Carbon, High Growth: Latin American Responses to Climate Change*. Washington, D.C.: World Bank, pp. 91–116.

117. Rogers, K.H. (2003) A conceptual framework for the rehabilitation of degraded rivers in the Eastern Cape, South Africa. *African Journal of Aquatic Science*, 28(1), pp. 29–38. https://doi.org/10.2989/16085910309503712.

118. Rahman, A., Choudhury, I. A., & Khan, A. N. (2017). Environmental and economic benefits of rainwater harvesting. Journal of Environmental Science and Health, Part A, 52(10), 937-944.

119. Ramantswana, T., Mdingi, P., Maake, M., & Vuyani, P. (2021). Approaching Day Zero: Effects of Water Scarcity in Construction Projects in South Africa. Journal of African Real Estate Research, 6(1), pp.104-120. DOI: 10.15641/jarer.v6i1.976.

120. Rand Water. (2017). Water pollution and your health [WWW Document]. URL http://www.randwater.co.za/corporateresponsibility/wwe/pages/waterpollution.a

121. Savenije, H. H. G., & Van der Zaag, P. (2002). Water as an economic good and demand management: Paradigms with pitfalls. Water International, 27(1), 98–104.

122. Sheng, Z., Zhang, X., Zhang, Y., Huang, Y. & Liu, C. (2019) The significance of smart water meter in water resources management. *Water Resources Management*, 33, pp. 1521–1536. https://doi.org/10.1007/s11269-019-02206-0.

123. Singha, B. & Aljamal, O. (2020) A Review on Water Conservation and Consumption Behavior: Leading Issues, Promoting Actions, and Managing the Policies. *Proceedings of International Exchange and Innovation Conference on Engineering & Sciences, 6*. https://doi.org/10.5109/4102484.

124. SIWI. (2020). How Cape Town saved itself from Day Zero. Avail- https://siwi.org/latest/how-cape-town-saved-itself-from-day-zero/ Accessed 28, June 2020.

125. Smith, E., Brown, J., & Williams, A. (2019). The role of regulations in promoting sustainable practices. Journal of Environmental Management, 245, 37-45.

126. Smith, M. B., Brouwer, S., Jeffrey, P., & Frijns, A. (2018). Psychological drivers of water conservation: A literature review. Current Opinion in Psychology, 23, 135-140.

127. Social Housing as a Catalyst Towards Netzero Carbon Building in the Mitigation of Climate Change in South Africa Review Article. (n.d.). DOI: https://doi.org/10.18820/24150487/as29i2.8

128. Sourani, A., & Sohail, M. (2011). Barriers to addressing sustainable construction in public procurement strategies. Proceedings of the ICE - Engineering Sustainability, 164(4), 229-237. DOI: 10.1680/ensu.2011.164.4.229

129. Staddon, C., Everard, M., & van der Wal, R. (2019). Challenges in promoting rainwater harvesting: technical, regulatory and cultural barriers. Water Policy, 21(2), 352-366.

130. Sun, Z., Xu, K., & Wang, H. (2020). Stakeholder education and outreach programmes to increase acceptance and adoption of reclaimed wastewater systems in construction projects. Journal of Cleaner Production, 273, 122863.

131. Syme, G., Nancarrow, B. E., & Seligman, C. (2000). The evaluation of information campaigns to promote voluntary household water conservation. Evaluation Review, 24(6), 539-578.

132. Tanner, C.C. & Nguyen, M.L. (2018) Water Sensitive Urban Design: An Investigation of Current Systems, Implementation Drivers, Community Perceptions and Potential to Supplement Urban Water Services. *Urban Water Journal*, 15(9), pp. 928–940. https://doi.org/10.1080/1573062X.2018.1506949.

133. Turk, J. & Bensalem, R. (2002) The integration of water demand management into the urban planning process: the case of Tunisia. *Physics and Chemistry of the Earth, Parts A/B/C*, 27(11-22), pp. 981–987. https://doi.org/10.1016/S1474-7065(02)00094-7.

134. Turpi, A.R. (2020) *Cape Town has huge tracts of SANDF land lying unused, enough for 67,000 households*. Available at: https://www.safcom.co.za/news/cape-town-has-huge-tracts-of-sandf-land-lying-unused-enough-for-67000-households.

135. Tam, V. W. Y., & Lee, W. L. (2007). Constructing sustainable communities in Hong Kong: A strategic environmental management study. Journal of Environmental Management, 85(3), 787–798.
136. Teodoro, M. P. (2009). Drivers of household water conservation: The role of demographic, infrastructure, and water pricing characteristics. Water Resources Research, 45(10).
137. Tchobanoglous, G., Cotruvo, J. A., & Crook, J. (2014). Stakeholder education and outreach programmes to increase acceptance and adoption of reclaimed wastewater systems in construction projects. Water Science and Technology: Water Supply, 14(6), 1047-1055.
138. UN. (2003). Water for People, Water for Life. Paris: UNESCO, www.unesco.org/water/wwap/wwdr
139. UN. (2023). Global Sustainable Development Report 6 2023. Advance, Unedited Version 14 June 2023. Advance, Unedited Version 11 14 June 2023
140. UNICEF. (2021). Water Scarcity for All. Available: https://www.unicef.org/media/95241/file/water-security-for-all.pdf.
141. Utraja, M. (2010). The Greening of Urban Transport: Planning for Walking and Cycling in Western Cities. Ashgate Publishing.
142. Van den Berg, C. & Van Dijk, M.P. (2017) Resilience and revitalization of small towns in the Karoo, South Africa. *The Journal of Arid Environments*, 139, pp. 1–12. https://doi.org/10.1016/j.jaridenv.2016.12.006.
143. Van Gool, L. (2016) Smart Cities: A Key to a Sustainable Future or an Overblown Dream?', In: *Smart Cities as Democratic Ecologies*. UK.: Palgrave Macmillan, Cham, pp. 15–35.
144. Varis, O. & Kummu, M. (2020) Society: From water wars to transparent governance. *Nature*, 583, pp. 500-502. https://doi.org/10.1038/d41586-020-02082-4.
145. Vawda, Z., & Hugo, J. (2022). Evaluating the energy performance of social housing as a catalyst towards net-zero carbon building in the mitigation of climate change in South Africa. Acta Structilia, 29(2), pp. 226-259.
146. Wade, J., Hunter, R., Delgado, C., Spiegel, J., Xue, J. & Liu, R. (2021) Historical Analysis of the Causes of Water Scarcity in the North China Plain. *Water*, 13(1), 63. https://doi.org/10.3390/w13010063.
147. Wang, C., Lin, Y. &o Jiang, G. (2019) A Comprehensive Review of Membrane Fouling on the Nanoscale. *Nanomaterials*, 9(10), 1471. https://doi.org/10.3390/nano9101471.
148. Wang, X., Zhao, C., Xu, Q., He, Z., Zheng, X., Zheng, X. & Zheng, W. (2021) A Review of Energy Harvesting Technologies in Water Distribution Systems. *Frontiers in Environmental Science*, 9, 614546. https://doi.org/10.3389/fenvs.2021.614546.
149. Waylen, Thornback and Garrett. (2011) Water: An Action Plan for reducing water usage on construction sites. *Strategic Forum for Construction*. Available at: https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2021/02/SCTG09-WaterActionPlanFinalCopy.pdf.

150. White, S. (2014) *The Challenges of Urban Development and Planning in Mozambique', In: Urbanisation and Development in Asia, Africa and Latin America*. Dordrecht: Springer. pp. 141–156.

151. Winkler, T.S., Brouwer, R., Brugnach, M. & Biesbroek, G.R. (2018) [Do governance factors really matter for the effectiveness of adaptation measures addressing water challenges? Insights from cases in the Netherlands, Spain and Brazil. *Global Environmental Change*, 50, pp. 214-226. https://doi.org/10.1016/j.gloenvcha.2018.03.009.

152. World Health Organization (2018) Water, Sanitation and Hygiene in Health Care Facilities: Status in Low- and Middle-Income Countries and Way Forward. *World Health Organization*. Available at: https://www.who.int/water_sanitation_health/publications/wash-health-care-facilities/en/.

153. Walton, et al,. (2005). "Integrated assessment of urban sustainability", Journal of Engineering Sustainability, Vol. 152 No. 2.

154. Ward, K. C., Michelsen, A. M., & De Mouche, P. (2007). Water conservation in residential buildings: A literature review and case study analysis. Pacific Northwest National Lab.(PNNL), Richland, WA (United States).

155. Waidyasekara, A., Silva, L., & Rameezdeen, R. (2016). Water use efficiency and conservation during construction: drivers, barriers and practices. Built Environment Project and Asset Management, 6, 553-566. DOI: 10.1108/BEPAM-09-2015-0052 36. Young, R. A., & Loomis, J. B. (2014). Determining the Economic Value of Water: Concepts and Methods (2nd Edition). RFF Press, Routledge. DOI: 10.1016/j.wre.2015.04.002

156. Waylen, P. R., & McCartney, M. (2011). Dryland river regimes – Variability, ecological status and future prospects. Earth-Science Reviews, 103(3–4), 163–173.

157. Western Cape Government. (2018). Western Cape Sustainable Water Management Plan 2017-2022, https://www.westerncape.gov.za/eadp/files/atoms/files/WC%20Sustainable%20Water%20Management%20Plan%202018.pdf

158. Willis, R. M., Stewart, R. A., Panuwatwanich, K., Williams, P. R., Hollingsworth, A. L. (2011b). Quantifying the influence of environmental and water conservation attitudes on household end use water consumption. Journal of Environmental Management, 92, pp. 1996-2009, doi:10.1016/j.jenvman.2011.03.023.

159. World Bank. (2022). Water in Agriculture Data. Available from < https://www.worldbank.org/en/topic/water-in-agriculture>

160. WWF. (2017). Scenarios for the Future of Water in South Africa http://awsassets.wwf.org.za/downloads/wwf_scenarios_for_the_future_of_water_in_south_africa_v7_6_pf_1.pdf

161. Xing, et al,. (2007). "A framework model for assessing sustainability impact of a built environment", in Horner, M., Hardcastle, C., Price, A., & Bebbington, J. (Eds), International Conference on Whole Life Urban Sustainability and Its Assessment, SUE-

162. Yildirim, S., Avkan, E. & Balcik, F.B. (2020) The Role of Big Data and Artificial Intelligence in Smart Water Management. *Water*, 12(1), 62. https://doi.org/10.3390/w12010062.

163. Young, R. A., & Loomis, J. B. (2014). Determining the Economic Value of Water: Concepts and Methods (2nd Edition). RFF Press, Routledge. DOI: 10.1016/j.wre.2015.04.002

164. Zanin, L., Aminuddin, A., Zulaika, J., Ghazali, Z.A. & Noor, Z.M. (2021) Smart Water Metering as a Precursor to Sustainable Urban Water Management: An Implementation Case Study in Malaysia. *Sustainability*, 13(11), 5916. https://doi.org/10.3390/su13115916.

165. Ziolkowska, J.R., Yap, D. & Moench, M. (2020) Adaptation to urban heat islands: Lessons from approaches taken in New York City, Berlin and Singapore. *Urban Climate*, 33, 100665. https://doi.org/10.1016/j.uclim.2020.100665.

166. Zhang, X., Zhang, X., Yang, L., Xu, C., Zhao, H., & Zhang, L. (2011). Assessing water resource allocation and its institutional arrangement in the Yellow River Basin, China. Environmental Management, 48(1), 30–43

APPENDIX

Table 1. **Gender representation**

Gender	Frequency	Percentage
Male	70	70,2
Female	31	29,8
Total	104	100.0

Table 2: **Age group representation**

Valid Age Group	Frequency	Percentage
Under 25	8	7,7
25-30	37	35,6
31-50	53	51,0
51-60	5	4,8
60+	1	1.1
Total	**104**	**100.0**

Table 3: **Education Attainment**

Valid Age Group	Frequency	Percentage
Matric	4	3.8
Diploma	15	14,4
Bachelors	64	61,5
Honours	13	12,5
Masters	5	4,8

Doctorate	1	1.0
Others	2	1,9
Total	104	100.0

Table 4: **Representing**

Valid Age Group	Frequency	Percentage
Contractors	57	56,7
Others	45	43,3
Total	104	100.0

Table 5: **Period of working in the current position**

	Frequency	Percentage
Less than 5 years	31	33,7
5 to 10 years	36	39,1
Over 10 years	25	27,2
Total	92	100.0

Part of the local government housing project

Valid response	Frequency	Percentage
Yes	73	79,3
No	19	20,7
Total	92	100.0