



**INVESTIGATING FACTORS INFLUENCING SUSTAINABLE DEVELOPMENT,
PERFORMANCE, AND DELIVERY PROCESSES OF GREEN CONSTRUCTION
PROJECTS IN SOUTH AFRICA**

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A minor dissertation presented to the Department of Construction Economics and Management in partial fulfilment of the requirements for the award of the degree of Master of Science in Project Management

August 2023

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Abstract

The construction industry has taken a step towards the implementation of green buildings to reduce the negative environmental impact of buildings and to achieve sustainable development. Green building certification is gaining traction globally and in South Africa. It has become a requirement for some private and government-owned buildings. Even though green certification is still voluntary, it is desired that more buildings obtain the green certification to measure environmental sustainability performance during the different phases of the building's lifecycle. However, there is limited research on the factors that influence the quest for the development of sustainable buildings in South Africa. Therefore, this research evaluates critical factors influencing sustainable development, performance, and delivery processes of green construction projects in South Africa. A comprehensive literature review was conducted to identify the factors influencing the development of green construction projects. Thereafter, a questionnaire survey was developed based on these factors. The targeted population for this study were Green Star accredited professionals who are registered with the Green Building Council of South Africa (GBCSA). This study employed cluster random sampling to divide the entire population into geographical regions that contribute to green infrastructure development. The questionnaire was administered online to 97 Green Star accredited professionals who reside within the Gauteng and Western Cape provinces. The data collected were analysed by means of descriptive and inferential statistics. The study revealed that the top ten factors influencing sustainable development, performance, and delivery processes of green construction projects in South Africa are: energy efficiency; water conservation; health and safety in the workplace; enforcement of green building codes and regulations; expressed interest from clients; effective stormwater management; an effective waste management plan for waste diverted to landfills; effective communication and engagement among project stakeholders; professional knowledge and experience in green buildings; and benefits of green buildings techniques. It also emerged that there is a significant relationship between these factors, sustainable development, and the sustainability performance of green construction projects. Based on these findings, the study concludes that clients and project stakeholders with knowledge of the factors influencing the development of green buildings are likely to develop green and sustainable projects.

KEY WORDS: Green building, green construction, Green Star, project delivery process, sustainable development, sustainable construction, sustainability performance

Acknowledgements

I would like to express my sincere gratitude to my Supervisor, Professor Abimbola Windapo for her invaluable input, continuous guidance, and meticulous attention to detail during the development of this dissertation. I am deeply grateful to the Western Cape Government Department of Transport and Public Works for offering financial assistance in funding my studies. I would like to acknowledge and thank my husband and my best friend, Silakhe Singata. He has been instrumental in the successful completion of this dissertation. He believed in me and consistently encouraged me to work hard to achieve my true potential. To my family, in-laws, and mother, Nomakhaya Mntuwenkabi: thank you for your unwavering love, support, and encouragement. Lastly, I would like to extend my appreciation to the respondents who have taken time to participate in the questionnaire survey and provided significant input.

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Definition of Terms

Carbon emissions: Emissions produced from the combustion of fossil fuels (coal, oil, and natural gas) (Bungau et al., 2022).

Climate change: Climate change refers to long-term changes in temperatures and weather patterns. (UNEP, 2021).

Electricity and Water Performance (EWP): This certification process was developed as an energy and water standard performance tool for existing buildings, including office buildings (GBCSA, 2022b).

Embodied carbon: Carbon emitted in the production of construction materials using fossil fuels for the extraction and manufacturing, transportation, installation, maintenance, and disposal of construction materials (Cao, 2017)

Excellence in Design for Greater Efficiencies (EDGE): This certification tool is an online green building rating software platform that provides a measurement tool to create resource-efficient buildings and enable developers to determine the financial viability of incorporating green aspects in projects (GBCSA, 2022b).

Green building: A green or sustainable building is a building which eliminates negative environmental impacts, and employs energy, water, and resource efficiency throughout its life cycle including design, construction, and operation (WGBC, 2022).

Green building technology: Use of sustainable technology to reduce environmental impacts of buildings and implement sustainability within the construction industry (Chan et al., 2017).

Green Star: The Green Star rating tool is used to assess environmental sustainability performance of buildings and awards points based on nine credits (i.e., management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, and innovation) (GBCSA, 2014).

Net Zero : Net Zero certification process is applied by the GBCSA to existing buildings, new construction, and fit out projects which have taken an initiative to neutralize their environmental impacts in terms of carbon, water, waste, and ecology (GBCSA, 2022b).

Operational carbon: Carbon emitted during the operational phase of a building (Cao, 2017).

Project delivery process: Project delivery process describes the stages that the projects typically undergo. These stages include initiation and briefing, concept and feasibility, design development, tender documentation and procurement, construction documentation and management, and project closeout (SACPCMP, 2019).

Sustainability performance: Sustainability performance in the built environment is a measure of the characteristics of a building needed to support the sustainable development objectives through its design, construction, operation, and maintenance. This can be examined in terms of environmental, social, and economic indicators (Tayeh et al., 2020).

Sustainable development: A development that aims to meet the present needs, without compromising the needs of future generations (Brundtland, 1987)

List of Abbreviations

BBBEE : Broad-Based Black Economic Empowerment

BIM : Building Information Modeling

BREEAM: Building Research Establishment Environmental Assessment Method

CASBEE: Comprehensive Assessment System for Built Environment Efficiency

CMR: Contractor Management at Risk

DB: Design Build

DBB: Design-bid-Build

DGNB: Deutsche Gesellschaft für Nachhaltiges Bauen e.V

EDGE: Excellence in Design for Greater Efficiencies

EWP: Electricity and Water Performance

GBCSA: Green Building Council of South Africa

GMS: Green Mark Scheme

IPCC: Intergovernmental Panel on Climate Change

LEED: Leadership in Energy and Environmental Design

MIS: Mean Item Score

SACPCMP :The South African Council of the Project and Construction Management Professions

SD : Standard Deviation

SPSS : Statistical Package for the Social Sciences

UN:United Nations

UNEP: United Nations Environment Programme

WCED: World Commission on Environment and Development

WGBC: World Green Building Council

SANS: South African National Standards

SDG: Sustainable Development Goals

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

In 2007, the Green Building Council of South Africa (GBCSA) introduced the concept of green building in property development, which is now being adopted as an emerging concept in the construction industry. The GBCSA aims to elevate sustainable development in the property industry by promoting green building programs, technologies, and design practices (GBCSA, 2017). This green approach to buildings is a response to the negative impacts of buildings on the environment. These negative impacts span environmental issues such as the energy crisis, water shortage, and climate change – which relate to global warming (Gunnell et al., 2009). The World Green Building Council (WGBC) defines a green building as a building which eliminates negative environmental impacts, and employs energy, water, and resource efficiency throughout its life cycle including design, construction, and operation (WGBC, 2022).

Green buildings have gained increased support in the construction industry globally because they reduce the negative impacts on the environment and thus achieve sustainable development (Darko et al., 2017). The United Nations (UN) on the report of the World Commission on Environment and Development (WCED) defines sustainable development as a development that aims to meet the present needs, without compromising the needs of future generations (Brundtland, 1987). This is based on three fundamental components, namely environmental protection, economic growth, and social equity. The technique for achieving sustainable development is through assessing the sustainability performance of a construction project throughout its life cycle (Shen et al., 2007).

Sustainability performance in the built environment is a measure of the characteristics of a building needed to support the sustainable development objectives through its design, construction, operation, and maintenance (Tayeh et al., 2020). Sustainability performance can be examined in terms of environmental, social, and economic indicators. The GBCSA technical manual (GBCSA, 2014), which provides guidance

for the evaluation a building's environmental impact, was used to select the environmental sustainability performance indicators (i.e., management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, and innovation). This manual includes a socio-economic framework that focuses on factors such as employment creation, economic opportunity, skills development and training, community benefit, empowerment, safety, and health, as well as mixed income housing (GBCSA, 2014). These socio-economic impact indicators were adopted in this research study.

In the assessment of the environmental sustainability performance of a building project, nine different performance indicators are used by the GBCSA. The management indicator, aforementioned, aims to encourage the implementation of policies, procedures, targets, and strategies that promote best practice sustainability outcomes throughout the operation of a building (Hoffman et al., 2020). The indoor environment quality indicator is in relation to the occupant's health and well-being (Lin et al., 2016). The energy indicator describes saving techniques that minimize CO₂ emissions (Ho et al., 2006). The transport indicator rewards the strategies that discourage automotive commuting while encouraging the use of alternative modes of transport such as public transport, walking, or cycling (Mathetha and Muzi, 2017). The water indicator describes provisions that reduce the use of potable water by utilizing efficient design systems such as rainwater harvesting, water reuse, and recycling (Shafiei et al., 2017). The material indicator refers to the use of recycled materials in the construction of buildings (Mwasha et al., 2011). The land use and ecology indicator describe initiatives implemented to improve or minimize the impact of buildings on ecological systems (Lin et al., 2016). The emissions indicator describes the approach used to manage and minimise environmental impacts of the building emissions to the atmosphere (Papadopoulos and Giama, 2007). The innovation indicator encourages technologies, initiatives, and processes that meet the objectives of sustainable construction (Shafiei et al., 2017).

Performance in green projects is achieved through the application of intense interdisciplinary collaboration during design, complex modelling and analysis, and careful selection of materials and systems, particularly in the initial stages of the project delivery process (Riley et al., 2004). The South African Council for the Project

and Construction Management Professions (SACPCMP) sets out the stages of project delivery processes as: initiation and briefing, concept and feasibility, design development, tender documentation and procurement, construction documentation and management, and project closeout (SACPCMP, 2019). There are factors that influence the sustainable development, performance, and delivery processes of green construction projects. As the adoption of green buildings rises in South Africa, there is a need to understand the critical factors that influence these parameters to enhance the design, construction, and operation of green buildings. The existing research will assist in identifying the influencing factors relating to the above-mentioned parameters.

The UN (2022) states that the world's population has been growing rapidly with approximately 7.9 billion people inhabiting the earth as of 2021. The UN projections confirm that by 2050, the world's population is expected to be 30% greater than in 2020. Globally, there are more people who reside in urban areas than in rural areas. The UN further illustrates that in 2018, an estimated 55% of the world's population resided in urban areas with the urbanization rate expected to rise to 68% of the world's population by 2050. The growth in population, which exerts a strain on resources, results in an unprecedented challenge to meet the demands of the present and future population by providing sustainable building capacity. The recognition of the impact of buildings on the economy, environment, and human health has made the implementation of sustainable buildings possible (Ziliya and Faisal, 2021).

Globally, the building sector accounts for 39% of carbon emissions whereas operational carbon contributes 28% and embodied carbon contributes 11% (WGBC, 2019). Operational carbon is emitted during the operational phase of the building while embodied carbon is emitted in the production of construction materials using fossil fuels for the extraction and manufacturing, transportation, installation, maintenance, and disposal of construction materials (Cao, 2017). WGBC (2019) proposes that by 2030 all new buildings should have at least 40% less embodied carbon and operate at net-zero carbon. Furthermore, to combat the climate breakdown, WGBC, suggests that all infrastructure, renovations, as well as new and existing buildings should reach net-zero for both embodied and operational carbon by 2050. Recognition of the urgent need to transition to a low-carbon and climate-resilient

economy is growing in South Africa along with achieving the Sustainable Development Goals (SDGs) to improve the lives of the continuously growing population. South Africa is in the top 15 of the world's highest carbon emitters and has joined other countries in the acceptance of the Paris agreement to limit global warming to 1.5°C by reducing carbon emissions . Intergovernmental Panel on Climate Change - IPCC (World Economic Forum,2022) states that the global temperature rises between 1.7°C to 1.8°C above 1850s levels, then it is likely that half of the global population could be exposed to life-threatening heat and humidity. IPCC further posits that if no immediate action is taken toward the reduction of greenhouse gas emissions, it is impossible to limit global warming to 1.5°C. Hence, realizing this goal of combating climate change will necessitate unprecedented cooperation among governments globally through employing abatement measures (International Energy Agency, 2022).

Natural resources are continually being depleted globally, which impacts sustainability (Lam et al., 2010). As a result of the expanding sustainability awareness globally, the green building approach has emerged as a sustainable solution for delivering buildings with reduced negative effects on the environment, resources, as well as public health (Zuo and Zhao, 2014). This is one of the approaches through which the construction industry contributes to sustainable development. Several researchers worldwide such as Lam et al. (2010), Shi et al. (2013), Simpeh and Smallwood (2015) cite different critical factors which impact the sustainable development of green construction projects. These critical factors are identified as additional costs which are associated with incremental time required in green building design, lack of industry knowledge of green building technology and its benefits, lack of interest from clients, limited availability of green material suppliers, and lack of support from the government. Implementing sustainable development within the built environment has resulted in the introduction of new and innovative ways to integrate sustainability into building designs (Nilashi et al., 2015).

The GBCSA has created a sustainability rating system to facilitate the design, construction, and operation of green buildings in South Africa and Africa. This is categorised by the Green Star, Net Zero, Electricity and Water Performance (EWP), and Excellence in Design for Greater Efficiencies (EDGE) rating tools

(GBCSA, 2022b). GBCSA defines Net Zero as a certification process applied to existing buildings, new construction, and fit out projects which have taken an initiative to neutralize their environmental impacts in terms of carbon, water, waste, and ecology. EWP was developed as an energy and water standard performance tool for existing buildings, including office buildings. EDGE is an online green building rating software platform that provides a measurement tool to create resource-efficient buildings and enable developers to determine the financial viability of incorporating green aspects in projects (GBCSA, 2022b). This suite of rating systems and tools considers distinct categories to rate the building's overall environmental impact and is used to create a standard environmental performance measurement for green buildings with the aim of achieving sustainability.

The major focus at the national policy level is on societal issues such as poverty, unemployment, inequality, lack of education and skills, and poor health. In addition to the environmental performance, the GBCSA has incorporated the socio-economic impact category into the green building rating tools to be addressed throughout the design, construction, and operation processes of a green building as an optional additional category to supplement the extension of their sustainability vision (GBCSA, 2014). The green building certification process incorporates detailed requirements and specifications requiring additional tasks from the project teams, which results in increased complexity levels of the whole project delivery process (Seyis and Ergen, 2017). As a result of these complexity levels, green buildings encounter less successful project delivery (Zhang et al., 2019). As the building market grows, the sustainable building projects, particularly those including energy-saving and indoor environment quality systems, present additional requirements in the delivery process (Korkmaz et al., 2011). This growing number of sustainable and green projects requires an understanding of the impact of the delivery process on project outcomes (Tamur and Erzaij, 2021).

Project success is not only limited to team interaction and iterative planning; rather, the delivery process involves a substantial number of variables that can affect the overall outcome (Swarup et al., 2011). Critical factors found in the reviewed literature, that influence the delivery process of green construction projects are project owner, designer, contractor, and contract related. These include the level of knowledge of

project participants, increased completion time for green projects, additional cost associated with implementing sustainable building features (Zhang et al., 2019), and the level of communication, commitment, and integration of project participants (e.g., owner, designer, and contractor) towards the sustainability attributes (Wu et al., 2021). In a construction project, the correlation between the project participants is determined by the project delivery systems used (Zhang et al., 2019). The complexity of sustainable building projects requires diverse expertise and an elevated level of collaboration (Gunhan, 2019). Gunhan noted that this level of collaboration is achieved through the implementation of a procurement method that integrates both the design and construction in the project delivery process to achieve mutual project objectives.

Green construction has gained recognition over the recent years in South Africa (GBCSA, 2017). In practice, some green construction projects where green practices are implemented by conforming to the South African National Standards (SANS) requirements are not delivered sustainably. This is evident in buildings that are not certified in accordance with the GBCSA rating tools. This is because environmental sustainability principles are not considered in all the stages of the project delivery process starting from inception, design, construction phases, through to the commissioning and operation of the building. Most of the current research on the sustainability performance of green buildings conducted by Licina et al. (2021) and Patnaik et al. (2018) focuses on individual sustainability factors such as the indoor environment quality. Hurlimann (2008) and Cheng et al. (2016) focus on water-efficiency, while Oguntona et al. (2019), and Amoah and Smith (2022) focus on energy efficiency. Even though the abovementioned list is not exhaustive, there is not much research that provides a holistic view of the factors influencing the environmental and socio-economic performance indicators considered in the Green Star SA certification process. In addition, evaluation of factors influencing the delivery processes of green buildings is necessary to provide guidance for the proper implementation of green building projects. Due to the emerging interest in the certification of green buildings, this research seeks to investigate the factors influencing the sustainable development, performance, and delivery process of green construction projects in South Africa. However, this study is not only relevant in South Africa, as there is a global need to achieve sustainable development to maintain a sustainable future.

1.2 Statement of the Problem

The continually increasing urbanization rate exerts more strain on resources, and thus requires sustainable building development. Green buildings reduce the negative impacts on the environment and are a solution to sustainable building development. Meanwhile, the WGBBC aims to support the UN's Sustainable Development Goals through the implementation of green buildings. The GBCSA promotes sustainability through the Green Star rating tools. The Green Star certification of buildings is attained when buildings meet the sustainability performance criteria. Given that the adoption of green buildings plays a significant role in the achievement of sustainable development. This study posits that, in theory there seems to be a lack of knowledge and experience of green building and that restricts its development. In practice there are several factors that have a potential to influence the environmental and socio-economic performance of green construction projects. Due to these factors some building projects are not delivered sustainably and that hinders them from obtaining the Green Star certification. In addition, factors influencing their delivery processes need to be evaluated to ensure that professionals successfully implement green practices in projects. Therefore, this research examines the factors influencing the sustainable development, sustainability performance, and delivery processes of green construction projects in South Africa. The knowledge of country-specific critical factors affecting green buildings is useful in addressing the negative impact of buildings on the environment.

1.3 Research Question

What factors influence sustainable development, performance, and delivery processes of green building projects in the South African construction industry?

1.4 Research Hypothesis

This study aims to test the following research hypotheses:

H₁: There is a relationship between sustainable development and the factors existing in a green construction project environment.

H₂: There is a relationship between sustainability performance and the factors influencing the development of green construction projects.

1.5 Research Aim

Investigate the factors influencing sustainable development, performance, and delivery processes of green building projects.

1.6 Research Objectives

The study aims will be achieved through the following research objectives:

1.6.1 Research objective 1

Find out the level of contribution of green construction projects to sustainable development.

1.6.2 Research objective 2

Determine the level of performance of green construction projects in terms of sustainability.

1.6.3 Research objective 3

Ascertain the phases in the delivery process of green building projects with the highest environmental impact.

1.6.4 Research objective 4

Establish the factors influencing sustainable development, performance, and delivery processes in green building projects.

1.7 Research Method

The research method that will be adopted to achieve the objectives of this study is as follows:

1.7.1 Review of the related literature

A literature review of matters correlated to the research question and available information on the level of sustainable development, performance, and delivery processes of green construction projects internationally and in South Africa. The information from the reviewed literature will be used to develop a questionnaire survey.

1.7.2 Online questionnaire survey

This study makes use of a hypothesis and quantitative method. The research employs an online questionnaire survey in soliciting information from 97 experienced Green Star accredited professionals in the South African construction industry. The data used in the analysis were derived from the questionnaire survey. The collected data were entered into the Statistical Package for the Social Sciences (SPSS 28) software. The responses from the questionnaires were pre-coded as the respondents' names were not included in the study. The results obtained from SPSS were analysed and discussed. Subsequently, conclusions and recommendations were drawn from the evaluation of findings. SPSS was identified as the most suitable analysis software since it makes use of descriptive statistics such as the mean and the standard deviation which are used in the research analysis to describe the variables measured in the study. This study employs descriptive statistics, reliability (Cronbach's Alpha), Mean Item Score (MIS), and inferential statistics (Spearman's rho correlation) in analysing the data collected.

1.8 Limitations

The online questionnaire was sent to all 97 Green star accredited professionals within the Gauteng and Western Cape province, in South Africa. Although these provinces are leading in green infrastructure in South Africa, the collected data does not represent the perceptions of the built environment professionals who are involved in green construction projects in other provinces. Thus, the views of the participants may not be an accurate reflection of the experiences of the entire construction industry. Several participants did not provide their responses to the survey, and some declined due to the tight schedule during working hours. The period in which the data were collected served as a barrier as this may have affected the response rate.

1.9 Scope of the Study

This study is delimited to the South African construction industry in the Gauteng and Western Cape province. The Green Star accredited professionals listed in the GBCSA database were used as a sample frame for identifying survey respondents.

1.10 Significance of the Study

Green construction has gained recognition over the recent years in South Africa. Notwithstanding any reservations about going green, there are obvious benefits to taking this approach. Implementation of sustainable or green innovations can significantly reduce the negative impacts imposed by the construction industry in relation to the environmental, social, and economic aspects (Darko and Chan, 2017). The increasing world population causes an increase in resource consumption. Implementation of energy and water efficiency in future construction is cost-effective for a developing country like South Africa. The recurring national load shedding, water scarcity, and increase in construction material costs in South Africa serve as a constant reminder that resources cannot be taken for granted and must be used sparingly to maintain a sustainable future – if indeed green construction avoids climate breakdown and promotes energy, resources, and water efficiency. This line of thinking may help to devise effective strategies to promote the adoption of green buildings in South Africa.

1.11 Structure of the Research Report

The research report will be structured as follows:

Chapter 1: The Introduction chapter introduces a summary of the research topic, the background of the study, followed by a problem statement, the research question, aim, objectives, and a concise description of the research method of the study. The limitations, scope, and significance of the study are detailed, concluding with the structure of the final report.

Chapter 2: The Literature Review chapter presents a critical review of the existing literature on the factors influencing the sustainable development, performance, and delivery processes of green construction projects.

Chapter 3: The Research Methodology chapter details the methods that will be chosen for this research and the justifications for using an appropriate method. It will draw on fundamental issues and justification of the research approach that will be employed to address the topic at hand.

Chapter 4: This chapter presents the findings, analysis, and discussion of data collected from the online surveys.

Chapter 5: The Conclusion and Recommendations chapter presents the summary of the research, findings, conclusion, and provides recommendations for practice and a potential future study. This will be followed by a detailed list of references and an Appendix comprising of the Ethics approval and questionnaire.

1.12 Chapter Summary

This chapter provided an overview of the research topic and discussed the facts leading to the problem statement, research question, aim, objectives, hypotheses, research method, and limitations of the study. The scope of the study and an overall justification in conducting the research was outlined, concluding with the structure of the dissertation. The reviewed literature will be detailed in the next chapter.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter will review the existing literature on concepts related to the sustainable development, performance, and delivery process of green construction projects globally and in South Africa. Furthermore, factors influencing these concepts will be discussed to gather the information that will assist in addressing the research problem and research question. These concepts include: sustainable development; green buildings; the contribution of green building towards sustainable development; the sustainability performance of green construction projects and how it is measured; and the delivery processes of green construction projects.

2.2 Overview of Sustainable Development

Sustainable development is an old concept that gained traction through the report provided by the World Commission on Environment and Development (WCED). WCED describes 'sustainable development' as development that meets the present needs without compromising the needs of future generations (Brundtland, 1987). Sustainable development became a concern as the rapid population growth indicated an unsustainable future in terms of preserving natural resources for the present and future generations (Gibson, 2001). The Brundtland report introduced the definition of sustainable development to address the increased environmental concerns, along with social and economic issues concerning human development and enhancing the quality of life (Robinson, 2004).

A considerable amount of literature Brundtland (1987), Fischer and Amekudzi (2011), Abdelfattah (2018), Prizzia (2017), Purvis et al. (2019) acknowledges that sustainable development is achieved through the integration of the three interrelated pillars of sustainability which include economic growth, social equity, and environmental protection. Fischer and Amekudzi (2011) highlight that economic development refers to the implementation of practices that support economic growth while preserving social and environmental quality for present and future generations (Fischer and Amekudzi, 2011). This notion is further supported by Reffat (2004), who argues that

the strategy of sustainable development ensures that the adopted approaches of economic development benefit the local environment and quality of life.

The United Nations Environment Programme (UNEP) demonstrates that since 2015, more countries have adopted the concept of sustainable development by reducing significant carbon and energy-related emissions in the building and construction sector. As of 2021 more than 80 countries have developed and adopted green building codes and policies to improve energy efficiency, promote low-carbon, and use of resilient building materials (UNEP, 2021). As a result, lower operating costs is one of the top triggers for implementing green buildings globally and in South Africa . The UNEP further reports that progress has been made since 2019 toward the achievement of sustainable development of buildings. This is evident in the 13.9 percent increase observed in global green building certification and an 11 percent increase in energy efficiency investment. Despite these efforts, the achievement of sustainable development of buildings continues to be one of the biggest challenges facing the construction industry as these improvements are inadequate to reach the global goal of decarbonizing the building sector.

In practice there are some buildings that are not delivered sustainably as the GBCSA (2022a) statistics show that approximately 905 buildings are Green Star certified. One may argue that there are buildings that are not yet green certified due to several reasons but conform to the sustainability standards. However, the number of green certified buildings in South Africa provides an indication of the state of buildings in South Africa in terms of sustainability. Sustainable development in buildings is achieved through the improved levels of environmental sustainability performance which has gained attention in countries that seek to find a balance between the development of the built environment and environmental protection (Awuzie et al., 2021). Sustainability performance in buildings is assessed through the performance criteria indicators that are used to measure environmental impacts of the building. These performance indicators address specific environmental issues such as population growth, depletion of non-renewable resources and natural resources, urbanisation, pollution, geopolitical problems, loss of biodiversity, global warming, soil erosion, acid deposition, waste management, and indoor environment (Uher and Lawson, 1998).

2.3 Contribution of Green Construction Projects to Sustainable development

Studies show that the construction industry can play a significant role in sustainable development since construction highly contributes to economic development and has profound environmental and social impacts (Sev, 2009). The estimates by the UN indicate that 55% of the world's population currently resides in urban areas, with a projected increase to 68% by 2050 (United Nations Habitat, 2022). A direct impact of rapid population growth in urban areas is the increased demand for buildings including but not limited to health infrastructure, residential units, educational facilities, and commercial buildings. However, buildings contribute to greenhouse gases emissions that are detrimental to the environment as buildings account for approximately 40% of annual global CO₂ emissions (Ahmed Ali et al., 2020). In addition, the building and construction sector consumes energy, and it is estimated that 80% of global primary energy generated is produced by fossil fuels (Perera, 2018). The reduction of carbon and energy-related emissions of buildings mitigate the negative impact on the environment, economy, and society.

The building and construction sector has a significant role to play in mitigating these issues through the reduction of embodied carbon and net zero carbon by 2050 (WGBC, 2019). Research shows that one of the ways to mitigate environmental impacts is the implementation of green buildings (Ali et al., 2020). The WGBC aims to catalyse sustainability in the built environment in collaboration with over 75 green building councils WGBC (2017) deduced that the implementation of green building practices provides a solution to the climate change issue in terms of energy-use reduction, pollution reduction, resource-saving, and assisting in achieving the UN 2030 SDGs.

There are obvious environmental, social, and economic benefits to adopting the green building approach. WGBC (2017) emphasizes that the terms 'green buildings' and 'sustainable development' are interlinked as green buildings address the key requirements of sustainability. Sustainable development in buildings also involves environmental, economic, and social aspects. Incorporating sustainable development in buildings therefore enforces a change in the implementation of building design, construction, operation, maintenance, and demolition.

2.3.1 Environmental aspects

The construction industry has made efforts in response to environmental issues like climate change, to introduce green buildings that promote water conservation, energy efficiency, reduction of carbon emissions, use of alternative energy resources, natural resources conservation, manufacturing, and use of environmentally friendly materials (Awadh, 2017; Zhang et al., 2019). The implementation of green construction projects has contributed to the reduction of construction pollution, improved ecological benefits, and energy-saving by using clean energy to lessen the reliance on fossil fuels, thus reducing carbon emissions (Chen and Luo, 2020). The core of the green building transformation includes improving the energy efficiency and environmental performance (Darko and Chan, 2016). However, it also contributes to the social and economic aspects.

2.3.2 Economic aspects

The consideration of achieving sustainable development in the construction industry has introduced the principles of sustainable construction or green buildings, and thus encouraged building owners to reduce energy and utility costs through the implementation of energy and resource-efficient technologies (Gunhan, 2019). The implementation of green buildings creates job opportunities thereby increasing the number of employees in the state. This will contribute to economic growth as the government can earn more tax revenue (Shabrin and Kashem, 2017).

2.3.3 Social aspects

Efforts have been made to study the environmental and economic aspects of green construction. However, no equal attention has been paid to the social aspects of green construction (Karji et al., 2021). Karji et al. state that omitting the implementation of the social aspects of green buildings diminishes the goal of achieving sustainable development. The social aspects of green construction benefits the community through the creation of job opportunities. In addition to job creation, green construction introduces skills development for the locals (Shabrin and Kashem, 2017). Green construction has contributed to the human health through the

improved indoor environment quality, increased occupant productivity and well being, as well as decreased work absenteeism (Allen et al., 2015).

2.4 Sustainability Performance of Green Construction Projects

Sustainability performance of a building ensures that the building exhibits sustainable characteristics in its design, construction, operation, and maintenance. Sustainability performance of green construction projects is based on the environmental, economic, and social sustainability indicators.

2.4.1 Review of Green Building Rating Systems in use

As the sustainable designs of buildings continue to evolve, several Green Building Councils around the world have formulated a framework for a green building rating system to measure the environmental performance of buildings and incorporate sustainable development into the design and construction process of buildings (Ali and Al Nsairat, 2009). The Green Buildings Councils worldwide implement green building rating systems to certify green buildings and assess the sustainability performance of the buildings. These rating tools provide a framework for project stakeholders to include processes required to achieve sustainability performance of buildings. The following are examples of green building rating systems used in the construction industry worldwide: the Green Mark Scheme (GMS) in Singapore, German Deutsche Gesellschaft für Nachhaltiges Bauen e.V (DGNB), United States Leadership in Energy and Environmental Design (LEEDS), United Kingdom Building Research Establishment Environmental Assessment Method (BREEAM), Japan Comprehensive Assessment System for Built Environment Efficiency (CASBEE), and Green Star (Australia, New Zealand and South Africa) (Awadh, 2017). These vary in the application and evaluation process of the building performance. Despite their differences, these rating systems have a shared objective to ensure that green certified buildings reduce the overall environmental impact of buildings. Although, the green building certification has become a requirement and standard for other private and government-owned buildings, it is imperative to note that the green building certification process is voluntary (Florez, 2020).

Despite the various green building certification tools used worldwide, since the study involves green construction projects in South Africa, the green building rating tool that is of interest in this review is the Green Star SA rating tool used by GBCSA. The two most internationally recognised green building rating systems, which are the United Kingdom's BREEAM, and United States' LEED, will also be looked at as these are flexible and can be applicable to different regions. The green building rating tools and their evaluation categories are presented in Table 2. 1: Most used green building rating tools worldwide.

Table 2. 1: Most used green building rating tools worldwide

Name of Rating Tool	Developer , Year	Categories	Versions	Source
BREEAM	Building Research Establishment (BRE) in 1990.	Energy use Transport Water Ecology Land use Materials Pollution Health and well-being Management.	Offices Housing Healthcare Courts Industrial Units Prisons Retail Schools Multi-residential Neighbourhoods	http://www.breeam.org
LEED	United States Green Building Council (USGBC) in 1993.	Energy and atmosphere Water efficiency Sustainable sites Materials and resources Indoor environment quality(IEQ) Innovation	Offices Homes Neighbourhood development Retail Healthcare Schools	http://www.usgbc.org/LEED
Green Star	Green Building Council of Australia (GBCAUS) in 2003	Energy Transport Water Ecology and use Emissions Materials IEQ Management Innovation	Offices Retail Schools (Industrial buildings) (Mixed use residential) (Mixed use) (Healthcare)	http://www.gbcaus.org

(Source: Sebake,2009)

2.4.1.1 BREEAM

It is reported that BREEAM was the first green building rating system in the world and was developed in the United Kingdom in 1990. Thereafter, other green building rating systems were developed by other green building councils (Florez, 2020). This rating tool assesses sustainability performance based on energy use, transport, water, ecology, land use, material, pollution, health and well-being, as well as management. The certification rating for this tool ranges from acceptable, pass, good, very good, excellent, or outstanding (Sebake, 2009). As of 2022, BREEAM has certified over 600,000 buildings across 89 countries worldwide (Bre Group, 2022).

2.4.1.2 LEED

LEED is a green building rating system which was developed by the United State Green Building Council in 1998 (Florez, 2020). This rating tool assesses sustainability performance based on energy use, water consumption, sustainable sites, material and resources, indoor environment quality, and innovation. The certification rating for this tool ranges from silver, gold, and platinum. As of 2022, LEED has certified over 100,000 buildings across 180 countries worldwide (USGBC, 2023).

2.4.1.3 Green Star (South Africa)

The Green Star rating tool which was initially developed in Australia was adopted in South Africa in 2009 to measure the sustainability performance of green building which includes Existing Building Performance, New Building and Major Refurbishments, Interiors, and Sustainable Urban Precincts (GBCSA, 2022b). The developed performance indicators used in the Green Star SA rating tools are the same as the performance indicators used by Green Star (Australia). The difference between the green building certification systems discussed above is insignificant. Table 2. 2: Key differences between Green Star and LEED shows the key differences between Green Star SA and LEED – the mostly used green building certification system as illustrated by (Bondareva, 2007).

Table 2. 2: Key differences between Green Star and LEED

	Green Star	LEED
1. Language of ratings	Stars and Literal descriptors	Figurative descriptors
2. Number of ratings	3	4
3. Focus	Sector-specific	Cross-sectoral
4. Scope	Tools for specific to life cycle phase	Tools for as-built attributes
5. Rating for Design	Available	Not available
6. Rating tool structure	8 Impact categories	5 Impact categories
7. Category weightings	Yes	No
8. Geographical adaptation	State-specific weightings	No geographical differentiation within tools
9. Credits	Unique credits such as “Design for Disassembly”	Unique credits such as “Locally- produced Materials
10. Calculators	Yes	No

(Source: Bondareva, 2007)

The GBCSA has made remarkable efforts to increase awareness around the sustainable development of green buildings to achieve sustainability in South Africa with certification levels including 4-star (best practice), 5-star (South African excellence), and 6-star rating (world leadership) (GBCSA, 2017). As of 2022, Green Star SA rating tool has certified over 905 buildings in South Africa and Africa (GBCSA, 2022). The sustainability performance indicators utilized by the GBCSA are management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, innovation. As mentioned above, most of the categories considered in Green Star certification are covered by LEED and BREEAM.

The Green Star rating tools were initially developed to assess the environmental performance of buildings. However, as the implementation of green building continues to grow, the GBCSA has incorporated socio-economic factors in the green building rating tools as an optional additional category to fulfil the sustainable development vision (GBCSA, 2014). The rating tools presented in Table 2. 1: Most used green building rating tools worldwide all have related categories except for the ‘health and well-being’ category included in BREEAM. However, this category is part of the Green Star SA Socio-Economic Impact Category tool.

The social and economic dimension is measured through the Socio-Economic Category (SEC) Pilot certification. SEC is an optional tool which is available in addition to the environmental sustainability assessment. GBCSA (2014) developed this certification for interiors and all new building green building projects that incorporate socio-economic achievements and initiatives. The categories of the SEC certification can be applied to the projects that qualify for the Green Star tools such as Office v1.1; Retail Centre v1; Multi-Unit Residential v1; Public and Education Building v1; Interiors v1; Custom Green Star Tools. The developed categories are employment creation, economic opportunity, skills development, and training, community benefit, implementation of Broad-Based Black Economic Empowerment (BBBEE) principles, improved health and safety for construction workers and the creation of mixed-income housing options (Applicable to multi-unit residential projects).

2.4.2 Green Star building certification programme in South Africa

The GBCSA launched the Green Star rating system in 2009, and to date the organization has managed to reach approximately 905 certifications in Africa across the Green Star, Net Zero, EWP, and EDGE certification categories. Carbon emission reductions, energy efficiency, and water efficiency have been achieved through sustainable buildings (Amoah and Smith, 2022). Amoah and Smith point out that the GBCSA promotes environmentally responsible practices through the implementation of the Green Star rating tools, training, and accreditation of approximately 2265 green building professionals to date.

The focus areas of the Green Star rating tools include the Existing Building Performance, New Building and Major Refurbishments, Interiors, Sustainable Urban Precincts, and Socio- Economic Category. However, for the purposes of this research, the Green Star rating tools of interest are the 'new buildings and major refurbishments' and 'sustainable urban precincts' Green Star rating tools. The new buildings and major refurbishment rating tool focused on the building's design, construction, and procurement phase while the sustainable precinct Green Star rating tool supports the environmental initiatives of a building's planning, design, and construction phase.

These phases included in the building performance form part of the delivery process of green construction projects.

2.5 Delivery Processes of Green Construction Projects

The implementation of sustainable buildings is an emerging approach in the construction industry. The delivery process of green buildings may be deemed complex as it requires processes such as additional site precautions, incorporation of energy efficiency, flexible design, and simulations to attain sustainability objectives (Zhang et al., 2019). Project delivery process refers to the integrated approach implemented to deliver a project. The SACPCMP (2019) defines this integrated approach as a set of various stages which include initiation and briefing, concept and feasibility, design development, tender documentation and procurement, construction documentation and management, as well as project closeout. The green construction projects have a similar delivery process, and a typical green project delivery process provided by Robichaud and Anantatmula (2011) is shown in

Figure 2.1.

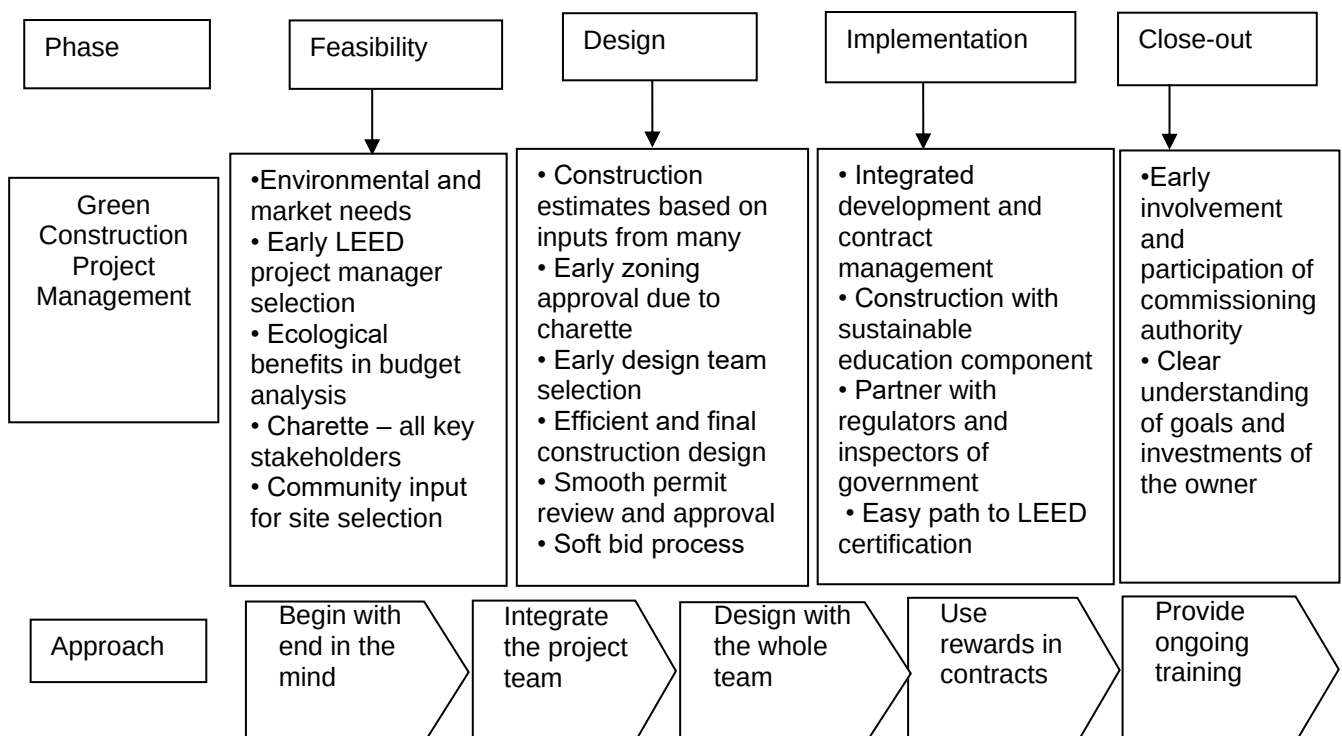


Figure 2. 1: Typical green construction project delivery process (Source: Robichaud and Anantatmula,2011)

There are no defined procurement methods to deliver green building projects. However, Swarup et al. (2011) and Gultekin et al. (2013) state that green projects delivered by the Construction Management at Risk Method (CMR) and Design-Build method (DB) have a greater probability of yielding better outcomes than projects delivered by Design-Bid-Build (DBB) method which is also known as the traditional method. This is due to the fragmented approach of the traditional method where there is no collaboration between the designer and contractor (Raouf and Al-Ghamdi, 2019). As opposed to the traditional method, the CMR method can produce a medium level of stakeholder integration while the DB method can produce an elevated level of integration among project participants (contractor and designer) early in the design process (Korkmaz et al., 2011). Although in the CMR method the contractor provides significant construction input during the design process, Gunhan (2019), argues that the DB method has proven to be the most well-suited method for sustainable construction projects as it integrates both the design and construction to ensure that these are cost-effective and meet the client's sustainability requirements. After the appropriate procurement delivery method has been selected, the design and construction phases follow.

The design of green construction projects considers the green building index criteria which include the building energy efficiency, indoor environment quality, sustainable site planning, and management, material and resource efficiency, water efficiency and innovation (Halil et al., 2016). One of the important aspects in the design and construction phases of green construction projects is the understanding of the green building requirements by the project team. These green requirements can impact the building's lifecycle and the third-party green building rating system.

Project construction activities also contribute to the global environmental issues. Hence, it is imperative that careful consideration is taken during the design and construction phase to ensure that buildings are delivered in a sustainable manner (Ahn et al., 2016). There are different construction methods used in projects and a specific construction method adopted in a project impacts project delivery. Construction methods adopted in projects include cast in-situ on-site, which has been associated with unsustainable construction due to higher greenhouse emissions

(Shen et al., 2009). Precast construction utilizes precast elements which are fabricated either on or offsite while prefabricated construction utilizes materials prefabricated offsite. The difference between precast off-site and cast in-situ on-site construction methods is the increased energy consumption of cast-in-situ buildings (Wang et al., 2020). Studies reveal that substituting cast in-situ on-site by precast off-site method would reduce construction waste as well as operational costs (Wong and Loo, 2022).

As a way of improving project delivery in the built environment, professionals are starting to adopt Building Information Modeling (BIM) software tool which is a collaborative work method to integrate the processes of an organization and digital representations of projects (including modelling, schedule, costs). BIM serves as a platform for efficient access to project information and enhances communication among project stakeholders (Dalirazar and Sabzi, 2022). Mtya and Windapo (2019) deduced that BIM adoption in South Africa is still in its infancy as construction firms have not fully adopted BIM in the delivery of projects. In a study conducted by Cao (2017), the researcher states that even though BIM is an emerging concept in the construction industry, it has been identified as a useful software tool that is utilized in green building construction process.

2.6 Overview of Factors impacting Sustainable Development, Performance, and Delivery Processes of Green Construction Projects

Waas et al. (2011) point out that there is a further conundrum that exists in delaying the transition towards a sustainable future which will create difficulty in achieving sustainable development. Studies show that the achievement of sustainability is not a once-off phenomenon: it is a recurring process that requires the willingness of humanity to manage resources in a sustainable manner (South African Department of Environmental Affairs and Tourism, 2008). The reviewed literature focused on three aspects which are sustainable development, performance, and delivery processes of green construction projects. Since the green building rating systems assess the sustainability performance of buildings throughout a building's lifecycle with the aim of achieving sustainable development in buildings. It is imperative to investigate the factors that impact on the sustainable development, sustainability performance, and

delivery processes of green construction projects. These factors are detailed in the following sub-sections.

Factors affecting the sustainable development, sustainability performance, and delivery processes of green construction projects were found to be similar in the literature. Instead of listing the same factors for each key element examined by the study, the common factors that apply to all aspects investigated were consolidated in one table (as shown in Table 2.3 to Table 2.8) . These are classified in terms of knowledge and awareness, as well as governmental, economic, financial, technical, social, and environment related factors. These were used to develop a questionnaire for use in evaluating the influence of these factors on green construction projects in South Africa. The knowledge of these factors which exist in the green project environment globally and in South Africa is imperative for the built environment professionals to achieve sustainability in buildings.

2.6.1 Environment-related factors

Table 2. 3: Environmental-related factors impacting sustainable development, sustainability performance, delivery processes of green construction projects

Environmental-related factors	Nilashi et al. (2015)	Zenios and Allen (2016)	Polat et al. (2017)	Dosumu and Aigbavboa (2018)	Tayeh et al. (2020)	Owusu-Manu (2022)
Reuse and recycling of construction materials	X	X			X	
Inclusion of water-saving initiatives on-site	X		X	X		X
Implementation of a management plan for waste diverted to landfills		X	X		X	X
Utilization of energy-saving techniques	X		X	X		X
Finding a location-efficient site for a green building	X	X				X
Implementation of effective stormwater management						X
Use of land with low ecological value		X			X	

Table 2. 3 presents a list of environmental-related factors impacting the key elements examined by the study. A brief description of the factors is presented below:

2.6.1.1 Reuse and Recycling of Construction Materials

Green buildings use renewable materials that contribute to reduced energy consumption and carbon emissions. The use of green construction materials, and its reuse and recycling process, is evolving as the demand for green materials continues to grow (Nilashi et al., 2015; Zenios and Allen, 2016; Tayeh et al., 2020).

2.6.1.2 Inclusion of water-saving initiatives on-site

Green buildings promote water efficiency using water-saving resources (greywater and rainwater recycling) and technologies (waterless fixtures, low-flow aerators, drip irrigation), thus reducing indoor potable water demand and consumption (Nilashi et al., 2015; Polat et al., 2017; Dosumu and Aigbavboa, 2018; Owusu-Manu, 2022).

2.6.1.3 Use of a management plan for waste diverted to landfills

Green buildings use effective waste management plan which outlines a procedure for the management of construction and demolition waste. The hierarchy of the integrated waste management methods include: reduction of waste generation, separation of potential recyclable materials at source for reuse, compost, incineration, with waste then being diverted to landfills (Zenios and Allen, 2015; Chen et al., 2017; Polat et al., 2017; Tayeh et al., 2020; Owusu-Manu, 2022).

2.6.1.4 Utilization of energy-saving techniques

The energy saving solution incorporated in green buildings promote energy efficiency thus reducing the need for energy consumption. These include the use of renewable energy sources and incorporation of energy-efficient features (Nilashi et al., 2015; Polat et al., 2017; Dosumu and Aigbavboa, 2018; Owusu-Manu, 2022).

2.6.1.5 Positioning/location-efficient site for a green building

Nilashi et al. (2015), Zenios and Allen (2016), and Owusu-Manu et al. (2022) view the surroundings of the proposed building site as a significant factor that must be considered in site selection since structures such as trees and other neighbouring buildings could obstruct sunlight and solar systems.

2.6.1.6 Implementation of effective stormwater management

The study conducted by Owusu-Manu et al. (2022) reveals that the most essential green construction practices in stormwater management include the use of green roofs, rainwater harvesting, and the use of permeable pavement.

2.6.1.7 Use of land with low ecological value

Green construction materials (recycled plastic, reclaimed wood and steel, and precast concrete) enhance the environmental ecological benefits such as reduced carbon footprints due to recycling and the reuse of construction waste, as well as enhanced air and water quality due to pollution reduction (Nilashi et al., 2015; Zenios and Allen, 2015; Dosumu and Aigbavboa, 2018; Tayeh et al., 2020; Owusu-Manu, 2022).

2.6.2 Social-related factors

Table 2. 4: Social-related factors impacting sustainable development, sustainability performance, delivery processes of green construction projects

Social-related factors	Korkmaz et al. (2011)	Hwang and Tan (2012)	Celik, (2013)	Darko and Chan (2017)	Zhang et al. (2019)
Health and safety in the workplace	X			X	
Community input during site selection			X		
Effective communication and engagement among project stakeholders	X	X	X	X	X

Table 2.4 presents a list of social-related factors obtained from the literature. A brief description of the factors is presented below:

2.6.2.1 Health and safety in the workplace

Health and safety in the workplace is one of the social benefits associated with green buildings. Green buildings contribute to health and well-being through enhanced comfort and indoor environment quality (Korkmaz et al, 2011; Darko and Chan, 2017).

2.6.2.2 Community input for natural resources protection during site selection

(Attaran and Celik, 2013) view the public or the community as significant stakeholders who should be included in the site selection process as the public and building occupants are directly impacted by the sustainability outcome of the building.

2.6.2.3 Effective communication and engagement among project stakeholders

Effective communication amongst the project team (i.e., owner, designer, contractors, and end-users) is required since every team member must have an in-depth comprehension of green construction projects (Korkmaz et al, 2011; Hwang and Tan, 2012; Celik, 2013; Darko and Chan, 2017; Zhang et al., 2019).

2.6.3 Economic and financial-related factors

Table 2. 5: Economic and financial-related factors impacting sustainable development, sustainability performance, delivery processes of green construction projects

Economic and financial-related factors	Shi et al. (2013)	Zenios and Allen (2016)	Darko and Chan (2017)	Dosumu and Aigbavboa (2018)	Simpeh et al. (2020)
Availability of information on opportunities and economic benefits of green buildings.					X
Availability of empirically proven cost data for green buildings.			X		X
Availability of green material suppliers	X	X	X	X	
Availability of locally sourced green building material.	X		X		
Funding for construction.		X			
Financial risks and uncertainties of rate of return of green investment and payback period.			X		X

Table 2. 5 presents a list of economic and financial-related factors influencing the key elements examined by the study. A brief description of the factors identified in Table 2. 5 is presented below:

2.6.3.1 Information on opportunities and economic benefits of green buildings

Simpeh et al. (2020) note that there is inadequate information on green building opportunities and economic benefits and this is caused by a lack of quantitative documentation of benefits and uncertainties associated with green construction.

2.6.3.2 Availability of empirically proven cost data for green buildings

Darko and Chan (2017) and Simpeh et al. (2020) state that there is inadequate availability of empirically proven cost data for green buildings and this impedes the growth of green buildings.

2.6.3.3 Availability of green material suppliers

A significant amount of literature (Shi et al., 2013; Zenios and Allen, 2016; Darko and Chan, 2017) confirm that green materials and products are vital for green construction. However, there is a limited availability of green material suppliers and this hinders the development of green construction projects.

2.6.3.4 Availability of locally sourced green building materials

In addition to the limited availability of green material suppliers, there is a limited availability of locally sourced green building material (Shi et al., 2013 and Darko and Chan, 2017) . Locally sourced green building materials reduce the negative impact on the environment that would be caused from transportation.

2.6.3.5 Funding for construction

Availability of more financing options for green construction is one of the top drivers of green construction projects. However, (Zenios and Allen, 2016) point out that various

organisations experience difficulty with the implementation of green construction projects due to funding.

2.6.3.6 Financial risks and uncertainties of rate of return of green investment and payback period

Simpeh et al. (2020) points out the uncertainty of rate of return on investment and payback period in green building projects. Darko and Chan (2017) argue that green buildings have a reduced payback period while Chițimiea et al. (2021) deduced that the payback period in green construction is much longer.

2.6.4 Knowledge and awareness- related factors

Table 2. 6: Summary of knowledge and awareness-related factors impacting sustainable development, sustainability performance, delivery processes of green construction projects

Knowledge-related factors	Lam et al. (2010)	Korkmaz et al. (2010)	Hwang and Tan (2012)	Darko and Chan (2017)	Zhang et al. (2019)	Simpeh et al. (2020)
Professional knowledge and experience/skills in green buildings (including client, designer, and contractor).	X	X	X	X	X	X
Knowledge of software to prepare green building designs (e.g., Life-Cycle Analysis tools, Building Information Modelling (BIM)).					X	
Availability of research data on sustainable building methods and green technologies	X		X	X		X
Inclusion of education/training for operation and maintenance staff, and end-user				X		X
Expressed interest, and demand from clients.	X		X	X		X
Public awareness of environmental issues and benefits of using green technologies.			X	X		X
Public concerns on the quality and performance of green materials.	X			X		

Table 2.6 presents a list of knowledge and awareness-related factors influencing the key elements examined by the study. A brief description of the factors identified in Table 2. 6 is reviewed and presented below:

2.6.4.1 Professional knowledge and experience/skills in green buildings

The knowledge and awareness of green buildings is essential for all stakeholders (including client, designer, and contractor) involved in a green construction project. Limited knowledge could prevent the successful implementation of green construction techniques and strategies (Lam et al., 2010; Korkmaz et al. ;2010); Hwang and Tan, 2012; Darko and Chan, 2017; Zhang et al., 2019; Simpeh et al., 2020).

2.6.4.2 Knowledge of software to prepare green building designs (e.g., Life-Cycle Analysis tools, Building Information Modelling (BIM))

BIM is increasingly being implemented in green building design as it provides higher productivity in the process of building design by integrating the design, procurement, construction, as well as operation and maintenance practices (Zhang et al., 2019;).

2.6.4.3 Availability of research data on sustainable building methods and green technologies

Lack of information due to inadequate research on green buildings contributes to the difficulty of acquiring expert knowledge thus decreasing public awareness (Lam et al., 2010; Hwang and Tan, 2012; Darko and Chan, 2017; Simpeh et al., 2020).

2.6.4.4 Inclusion of education/training for operation and maintenance staff, and end-user

Darko and Chan (2017) note that increased education and training has become a driving force behind GB development. Some researchers argue that there is a lack of training and support provided for green building operations (Simpeh et al., 2020).

2.6.4.5 Expressed interest, and demand from clients

Knowledge of green building serves as a driver of interest and market demand of green buildings from a client/owner point of view (Simpeh et al.,2020). Several researchers

point out that there is a lack of interest and demand of green buildings from clients (Lam et al., 2010; Hwang and Tan, 2012; Darko and Chan, 2017).

2.6.4.6 Public awareness of environmental issues and benefits of using green technologies

Lack of information on green buildings decreases public awareness (Darko and Chan, 2017). Hwang and Tan (2012); Simpeh et al. (2020) mention that public awareness is crucial as it contributes to high demand and improved project delivery.

2.6.4.7 Public concerns on the quality and performance of green materials

Lack of public awareness thereof leads to public concerns regarding the quality and performance of green buildings (Lam et al., 2010; Darko and Chan, 2017).

2.6.5 Governmental-related factors

Table 2. 7: Summary of governmental-related factors impacting sustainable development, sustainability performance, delivery processes of green construction projects

Governmental-related factors	Lam et al. (2010)	Hwang and Tan (2012)	Windapo and Goulding (2015)	Darko and Chan (2017)	Mathetha and Muzi (2017)	Zhang et al. (2019)	Simpeh et al. (2020)
Enforcement of green building codes and regulations.	X		X	X		X	X
Complexity of government legislative procedures and requirements of submission documentation.		X		X			X
Governmental support or incentives (e.g., tax, special loans, and grants) for promoting green buildings.	X	X		X		X	X
Funding for research and the implementation of green construction projects						X	X
Delay in approval of green building projects by local authorities	X						X
Collaboration between developers and transport planning authorities					X		

Table 2. 7 presents a list of governmental-related factors influencing the key elements examined by the study. A brief description of the factors is presented below:

2.6.5.1 Enforcement of green building codes and regulations

Windapo and Goulding (2015) identified a sample set of green building legislation used in South Africa, and established that a significant lack of knowledge on green building legislation and legislation requirements in South Africa exists. One of the issues with building codes and regulations is that some features of green buildings are seldom included, and this affects project delivery; hence, building codes and regulations that incorporate green building aspects are necessary to ensure effective project delivery (Lam et al., 2010, Darko and Chan, 2017; Zhang et al., 2019; Simpeh et al., 2020).

2.6.5.2 Complexity of government legislative procedures and requirements of submission documentation

The submission documents required for legislative procedures of green buildings is becoming more complicated which prevents developers from seeing the benefits of going green (Hwang and Tan, 2012; Darko and Chan, 2017; Simpeh et al., 2020).

2.6.5.3 Governmental support or incentives (e.g., tax, special loans, and grants) for promoting green buildings

Governmental support provides an external influence such that research proves that project team participants embrace the development of green buildings when there are incentives/ benefits attached to them (Lam et al., 2010; Hwang and Tan. 2012; Darko and Chan, 2017; Zhang et al., 2019; Simpeh et al., 2020).

2.6.5.4 Funding for research and the implementation of green construction projects

Simpeh et al. (2020) note that there is inadequate research funding on green buildings. A study conducted by Darko and Chan (2017) indicates that poor market demand for green buildings is due to the lack of credible research on green buildings techniques and strategies hence the government is required to provide subsidies for the research and development of green buildings.

2.6.5.5 Delay in approval of green building projects by local authorities

Research shows that there is a delay in obtaining approval and permits to execute green construction projects (Lam et al., 2010). Officials that are not well equipped with green construction techniques easily contribute to these delays (Simpeh et al., 2020).

2.6.5.6 Collaboration between developers and transport planning authorities

Some experts in the industry have indicated that the required submission for transport category is complicated thus requiring collaboration between developers and transport planning authorities (Mathetha and Muzi, 2017).

2.6.6 Technical-related factors

Table 2. 8: Technical-related factors impacting sustainable development, sustainability performance, delivery processes of green construction projects

Technical-related factors	Korkmaz et al. (2011)	Hwang and Tan. (2012)	Shi et al. (2013)	Zenios and Allen (2016)	Darko and Chan (2017)	Dosumu and Aigbavboa (2018)	Ayarkwa et al. (2022)
Preferred use of conventional methods					X		
Use of green building techniques	X	X	X	X	X	X	
Incremental time required in green building design		X	X				
Lengthy approval process of design drawings	X						
Lengthy green material specifications	X						
Lack of knowledge of the appropriate procurement delivery method for green construction projects	X						X
Slow tendering and procurement processes							X
Effective planning	X						
Scarcity of contractors and subcontractors with green building experience		X	X	X			
Early identification and involvement of key project stakeholders.			X	X	X		
Design flexibility against changes during the construction phase.						X	
Inclusion of the contractor in the design development phase.	X		X				

Table 2. 8 presents a list of technical-related factors influencing the elements examined in the study. A brief description of the factors identified in Table 2. 8 is reviewed and presented below:

2.6.6.1 Preferred use of conventional methods

Even though green construction is gaining attention, conventional methods are still much preferred as they make up the bulk of structural elements. Some professionals prefer traditional practices due to additional requirements required in green construction (Darko and Chan, 2017).

2.6.6.2 Preferred use of green building techniques

Green buildings do not only minimize carbon emissions. The implementation of green building techniques yields various benefits which include, but not limited to, improved indoor air quality, energy-saving, water efficiency, improved occupants' health, and wellbeing (Korkmaz et al., 2011; Hwang and Tan, 2012; Shi et al., 2013; Zenios and Allen, 2016; Darko and Chan, 2017; Dosumu and Aigbavboa, 2018).

2.6.6.3 Incremental time required in green building design

Hwang and Tan (2012) and Shi et al. (2013) argue that incremental time caused by green construction is one of the factors limiting the growth of green buildings.

2.6.6.4 Lengthy approval process of design drawings

Korkmaz et al. (2011) state that the lengthy approval process for green construction could affect the management of the project such as increased time of completion.

2.6.6.5 Lengthy green material specifications

As sustainability principles evolve and new green materials are being introduced material specifications continue to change. Green specification is not fixed, however; there are general attributes of green buildings which include sustainable use of

materials, improve water and energy efficiency, as well as waste and pollution reduction (Darko and Chan, 2016).

2.6.6.6 Lack of knowledge of the appropriate procurement delivery method for green construction projects

There is no definite procurement method to be used for green buildings. Several researchers have different opinions. Some state that the most appropriate delivery method to use is Design-Build (Korkmaz et al., 2011). Some research argue that stakeholders are more likely to implement traditional procurement methods to avoid additional responsibilities required in green construction (Ayarkwa et al., 2022).

2.6.6.7 Slow tendering and procurement processes

Ayarkwa et al. (2022) identified that there is a slow tendering and procurement process in green construction projects requiring knowledge of the appropriate procurement method.

2.6.6.8 Effective planning

Project planning directly impacts the success of a project The delivery process for green construction projects is more complex than conventional construction thus requiring advanced planning (Korkmaz et al. 2011).

2.6.6.9 Scarcity of contractors and subcontractors with green building experience

Hwang and Tan (2012) and Shi et al. (2013) deduced that there is usually a restrained pool for the selection of contractors and subcontractors with knowledge and experience in green construction projects. Zenios and Allen (2016) state that even though some contractors have delivered green construction projects, most contractors do not have experience in undertaking these projects.

2.6.6.10 Early identification and involvement of key project stakeholders

Integration of participants is significant to ensure that stakeholders have a clear understanding of the project requirements, especially in the early stage in the delivery of the project (Shi et al., 2013; Zenios and Allen, 2016; Dako and Chan, 2017).

2.6.6.11 Design flexibility against changes during the construction phase

Sustainable buildings incorporate the flexibility of changes at the design and construction stages. Incorporating design flexibility in projects is convenient when changes are required at a later stage (Dosumu and Aigbavboa, 2018).

2.6.6.12 Inclusion of the contractor in the design development phase

Korkmaz et al. (2011) and Shi et al. (2013) note that the early involvement of a contractor in the delivery processes is essential for the achievement of sustainable buildings.

2.7 Theoretical framework of the study

In a dissertation study, researchers develop a theoretical framework based on existing theory and empirical findings that reflect the research question of a study (Osanloo and Grant, 2016.). The theoretical framework is created prior to data collection to establish a rationale for the study and provide a basis for the literature review. The theoretical framework includes the variables of interest and their relation to each other. based on the broader theory (Simon and Goes, 2011).

This study seeks to examine factors influencing three key variables which are sustainable development, sustainability performance, and delivery processes of green construction projects. The theoretical framework that guides the study is a theoretical framework of sustainability principles of building developed by Isa et al. (2014).

2.7.1 Sustainability Principles of Building Model

The sustainability principles of building model developed by Isa et al. (2014), posits that a sustainable building design should integrate sustainable development (environment, social, economic) principles into the building project life cycle as demonstrated in the theoretical framework (Figure 2.2) to obtain a successful sustainable building project. The authors further emphasize the significance of conducting a building life cycle analysis to determine whether the building is delivered sustainably.

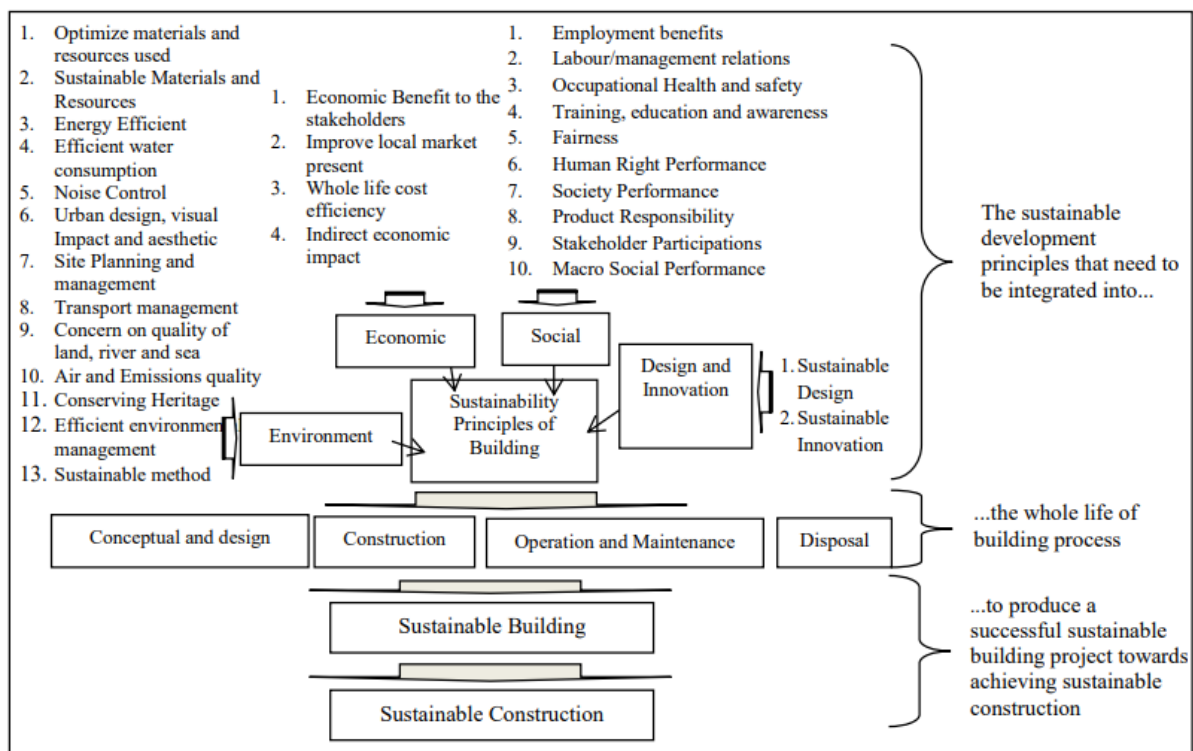


Figure 2. 2: A theoretical framework of sustainability principles of building (Source: Isa et al., 2014)

The reviewed literature and theoretical framework illustrated above will inform the research questionnaire. Subsequently, the results obtained from the collected data will be tested to determine the relationships between sustainable development, sustainability performance, delivery process and factors existing in a green construction project environment as stated in the research hypotheses (section 1.4).

2.8 Chapter Summary

The rapid population growth has evoked a sense of urgency in terms of building construction. Due to population growth which requires an increase in building capacity. Countries all around the world including South Africa are facing challenges of climate change, water shortage, and the energy crisis that results in persistent load-shedding. It emerged from the review that implementation of green construction will ensure the reduction of greenhouse gas emissions and the preservation of natural resources for the present and future generations. The reviewed literature provides an overview of the contribution of green construction projects to sustainable development in terms of environmental, social, and economic benefits. Furthermore, the study examined a theoretical framework to guide the study. The theoretical framework posits that the achievement of sustainable construction requires buildings to conform to sustainable development principles.

The sustainability performance indicators which are used to assess the performance of green construction projects were reviewed. These sustainability performance indicators were obtained from the Green Star rating tools used by the GBCSA and these are assessed based on separate phases of the project delivery process. The GBCSA has made efforts to promote the implementation of green buildings through the Green Star rating system. Although the reviewed literature shows that the number of green-certified buildings is increasing, there is still a long way to go in terms of ensuring that more buildings perform sustainably. This study was inspired by the fact that in practice some buildings do not perform sustainably owing to a lack of knowledge of factors that influence the sustainable development, performance, and delivery processes of green construction projects. The factors obtained from the reviewed literature were found to be similar for all three parameters being investigated in this research. There was limited research that investigated the relationship between these factors and the sustainable development, performance and the delivery processes of green construction projects. This is further investigated using empirical evidence.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the techniques and procedures implemented for the methodology of the study to achieve the research aim and objectives. A description of the suitable research approach, strategy, research design, research methods of data collection and analysis, study population, sampling methods, sampling techniques, evaluation of the reliability and viability of the research instruments, and ethical considerations will be provided in this chapter.

3.2 Research Approach and Strategy

Research approaches are plans and procedures followed by a researcher to inform the process of data collection, analysis, and interpretation of results (Creswell, 2014). Creswell classifies the common approaches to conducting research as quantitative, qualitative, and mixed methods. This study employed a quantitative method which seeks to answer research questions through the collection of numerical data that is analysed using statistical techniques to determine a relationship between variables involved (Williams et al., 2007). This approach tests theories deductively as the researcher investigates the problem by formulating hypotheses, collecting data, applying statistical analysis of the data, and drawing conclusions (Watson, 2015).

Sukamolson (2007) posits that the quantitative method relies on the positivist worldview. This worldview specifies that the researcher maximizes objectivity to uncover the existing theory and that requires the researcher to be detached from the research to avoid biases. Quantitative research approach is used to quantify data collected from larger population groups. The population groups are selected randomly, and data is collected by means of questionnaires and experiments. This method is used to test theories and or assumptions using numerical data analysed by means of descriptive and mathematical inferences while the qualitative research approach is used to understand concepts (Yilmaz, 2013). In this study, the researcher assumes that there are factors existing in a project environment that impact on the sustainable development, performance, and delivery processes of green construction projects.

3.3 Research Design

Research designs are types of inquiry within qualitative, quantitative, and mixed method approaches used by the researcher as a procedure to carry out the study (Creswell and Creswell, 2017). A research design is the blueprint or plan that is implemented by a researcher to conduct a study with the aim of answering a particular research question (Bloomfield and Fisher, 2019). According to Asenahabi (2019), there are two broad categories of research designs considered in quantitative research and those are experimental and non-experimental research designs. In an experimental study, the researcher measures subjects before and after treatment to determine the cause-effect relationship between variables (Marczyk et al., 2010). The process of data collection in the non-experimental design is divided into three categories which are: causal-comparative design, correlation design, and survey design (Asenahabi, 2019). A correlational study measures variables but seeks to establish the degree of association between specific variables involved (Creswell and Creswell, 2017). In causal-comparative research design, the researcher determines cause-effect relationship between variables (Khaldi, 2017).

A survey design collects information in the form of closed-ended questions and is commonly used to collect data from large population groups in a brief period (Chapman, 2005). Asenahabi (2019) mentions two survey research observations used by researchers to record and interpret data and those are cross-sectional and longitudinal studies. Observations in a cross-sectional study are carried out at a single point in time while a longitudinal study is carried out at different points in time showing the way in which data evolves over an extended period. The preferred research design for this study is the survey design. Survey research collects numerical data through scientific sampling and questionnaires to measure a sample of the population (Sukamolson, 2007). The survey method was employed in this study because the researcher identified the factors influencing the development of green construction projects from literature. To test if the factors exist in a green construction project environment, the perception of various respondents was required. Hence, this study relied on a cross-sectional study by making use of self-administered online questionnaire surveys with closed-ended questions – except for the last question which was open-ended as it sought to determine the respondents' opinions on the

research topic. The cross-sectional study method is used to collect data from different individuals simultaneously. In this study, the researcher collected and analysed questionnaire data to establish the correlation between the variables of interest.

3.4 Area of the study

The study was conducted in the Gauteng and Western Cape provinces, South Africa. The major cities in these provinces are economic powerhouses and contain the majority of Green Star SA certified developments in South Africa.

3.5 Study Population, Sampling Technique and Size

3.5.1 Study population

Study population refers to a group of individuals who have a detailed understanding of the research variables involved in the study (Majid, 2018). The population for this study includes built environment professionals who implement green construction projects in South Africa. The built environment professionals were required to meet a set of criteria to address the research question. The professionals were required to have implemented a green construction project(s) in the last five years. A key requirement is to solicit information from built environment professionals who are registered with the GBCSA as Green Star SA accredited professionals. A Green Star accredited professional possesses a detailed knowledge and understanding of the green rating tools and advises project teams to implement sustainable measures that will assist a project in achieving a Green Star certification and improve the sustainability of the building.

3.5.2 Sampling technique

According to Etikan et al. (2016), when researchers conduct a study it is almost impossible to collect data from every individual in a population group of interest. This is where the importance of selecting a sample comes to view. Due to these reasons, researchers apply sampling techniques to reduce the number of population (Taherdoost, 2016). The sampling techniques assist the researcher in selecting a subset population group who will participate in the study. Kothari (2004) discusses

two sampling techniques used in research and these include probability sampling techniques and non-probability sampling techniques. Probability or random sampling makes use of random selection to select elements of a sample from a population of interest (Bell et al., 2022). Contrarily, non-probability sampling is not based on randomization it makes use of subjective methods to determine the elements to be involved in a sample (Kothari, 2004).

In this study, cluster random sampling was employed to divide the entire population into clusters and provide each element of a population an equal chance of being included in the sample. This sampling technique is beneficial for a researcher who conducts a study over a large geographical area (Taherdoost, 2016). In this research, the cluster grouping for sampling frame was selected to generalise results within a geographical region. The geographical region selected for the study includes the Gauteng and Western Cape provinces due to the growth in the number of Green Star SA certified buildings that contribute to infrastructure development in these provinces.

3.5.3 Sample size

It would be unrealistic to collect data from every individual in a population of interest, hence it is necessary to select a sample that will represent the study population (Knight and Ruddock, 2009). Sample size refers to the number of respondents involved in a study. The population of the study included Green Star accredited professionals across the various fields in the built environment. The GBCSA website lists 97 Green Star accredited professionals who currently reside in the Gauteng and Western Cape provinces and are registered within the 'new building and major refurbishments' and 'sustainable precinct' categories. Professionals who are registered within other Green Star categories – which include net zero, existing building performance, and interiors – were excluded from the survey as the questionnaire survey was directed to the planning, design, construction, and procurement phase of new green buildings. All 97 respondents (100%) were sent direct emails including a consent form and a link to the online questionnaire survey. Out of the 97 questionnaire surveys sent out, 48 professionals completed the online survey representing a 49% response rate. This 49% response rate is compatible with

the previous studies conducted by Watt et al. (2002), Nair and Adams (2009), Knight and Ruddock (2009), Ogier (2005) ; where a minimum of 20% response rate from online surveys was achieved and was considered adequate for data analysis. Screening of the responses was conducted, and it was determined that 12 respondents have indicated that they have recently qualified as Green Star accredited professionals and have not been fully exposed to the processes of green construction projects. Although, the 12 respondents had completed the survey, their responses were not beneficial for this research. Only 1 respondent indicated that they have not been directly involved in the implementation of green construction projects since 2014 and 2 of the responses were incomplete. After the screening process, the researcher was left with a sample size of 33. To determine the acceptable size for data analysis, a Central Limit Theorem was applied which states that the sampling distribution of the sample mean approaches a normal distribution as the sample size gets larger despite the distribution of the population. This theorem holds for a sample size of at least 30 and implies that when the sample size reaches 30, the distribution of the sample mean is the same as the normal distribution (Kwak and Kim, 2017). Therefore, the data analysis of this research is based on a sample size of 33 which is adequate based on the injunctions of the Central Limit Theorem.

3.6 Data Collection Methods

The purpose of data collection is to gather and measure information that will address the research questions, test hypotheses, and analyse the outcomes (Kabir, 2016). Kabir indicates that data collected in quantitative research is numerical in nature and can be analysed using mathematical statistics. Research instruments used for the collection of data include the administering of questionnaires. Questionnaires are suitable for studies that require a limited amount of data and present the same questions to each respondent (Knight and Ruddock, 2009). In this study, the questionnaire formed an integral part of the data collection method. A questionnaire is used in survey research to collect quantitative primary data from respondents in a form of standardized questions online, in person, or through mail (Roopa and Rani, 2012). The use of online questionnaire surveys as a primary data method provides a wide coverage allowing the researcher to solicit information from a large population at the

same time. The standardised questions allow the researcher to easily compile, manage, and analyse data. In this study, a questionnaire was used as the main research instrument of data collection to solicit information from the green projects conducted by the Green Star accredited professionals. A questionnaire format can be open-ended or closed-ended (Knight and Ruddock, 2009). Closed-ended questionnaires are much easier to code and analyse than open-ended questionnaires, as the researcher influences the respondent's opinion by presenting a standardized or fixed number of closed-ended questions which limit the respondents to a set of answers. While open-ended questionnaires consist of questions that do not limit the respondents to a set of answers offered by the researcher but allow the respondents to express their opinions and suggest information that may have been overlooked by the researcher. Research instruments in quantitative research can include face-to-face interviews, telephone interviews, and questionnaire surveys sent via email. The mode of completion of questionnaires can either be self-administered or interviewer administered (Meadows, 2003). The latter is administered by a researcher either face to face, telephone, or online while self-administered questionnaires are completed by respondents without being influenced by the researcher.

This study adopted a self-administered questionnaire through an online survey of closed-ended questions. Data collection was conducted over a period of 6 weeks from the 14th of October until the 23rd of November 2022. After 2 weeks of circulating the surveys to the targeted group, follow up emails were sent to ensure that adequate responses are attained as the questionnaire survey is solely dependent on the cooperation of the participants.

3.7 Research Instrument used in the study

The research employed the quantitative method approach. The researcher conducted a literature review and determined a fixed number of questions that are suitable for the study hence a closed-ended question was used as a suitable questionnaire format to achieve the research objectives. Questionnaires are beneficial for measuring the attitude of respondents towards research statements. (Stevens, 1955) introduced the four commonly used measurement scales which are interval, ratio, nominal, and

ordinal. Interval scale measures the distance (interval) between variables such as temperature in degrees Celsius or year. Ratio scale has the same characteristics as the interval scale with an addition of real absolute zero. Examples of ratio scale include variables such as age, height, or weight. Both the interval and ratio scale consist of numerical data. However, nominal scale refers to categorical data such as gender, sex, race, or educational background while ordinal scale refers to categorical and ranked data and can make use of Likert scales. The measurement scales for the data collected informs the appropriate analysis method to be selected. The summary of the questionnaire design is presented in Table 3.1.

3.7.1 Nominal scale

In the first section of the questionnaire of this study, nominal scale was used to determine the demographic characteristics of the respondents. It is important to distinguish between nominal scale and ordinal scale data as the nominal data does not represent any difference in degree between categories and ordinal scale represents the difference in degree between one category and another.

3.7.2. Ordinal scale

In this study, the research questionnaire survey utilized nominal and Likert scale data measured at the ordinal level. Likert scale was developed by Rensis Likert in 1932 and is one of the mostly used attitude scales (Knight and Ruddock, 2009). A Likert scale was used to measure the Green Star accredited professionals' knowledge and perception of green construction projects by presenting factors reported in reviewed literature. The research questionnaire is based on a five-point Likert scale where, 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low (Refer to Appendix C for the questionnaire used in the study).

Table 3. 1: Summary of the research questionnaire design

Question		Variable	Measurement Scale
Section 1: Demographic characteristics			
(1-6)	Respondent's background and organization profile	Gender, age, academic background, profession, type of organization, years of experience in the construction industry and green construction.	Nominal
(7-11)	Involvement in green construction projects	Building sector, Green Star accredited professional programme and year of registration, no. of projects implemented, and methods of professional development.	Nominal
Section 2: Factors influencing the sustainable development, performance, and delivery processes of green construction projects			
(12-14)	Project specific	Completion, date, and Green Star rating tool.	Nominal
15	Sustainable development	Environmental, social, and economic aspects of green construction projects	Ordinal. Five-point Likert scale: 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low
16	Environmental and socio-economic sustainability performance	Based on the 9 categories of the GBCSA Green Star rating tools	Ordinal. Five-point Likert scale: 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low
17-19	Delivery processes	Construction and procurement delivery method.	Nominal

Table 3. 1: Summary of the research questionnaire design (cont'd)

Question		Variable	Measurement Scale
Q20.1	Knowledge and awareness of green construction projects	Professional knowledge and experience in software, education and training, demand from clients, public awareness.	Ordinal. Five-point Likert scale: 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low
Q20.2	Governmental policies and regulations	Green building codes, legislative procedures, government, delay in approval, collaboration.	Ordinal. Five-point Likert scale: 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low
Q20.3	Social and economic aspects of green construction projects	Community engagement, health and safety, communication among stakeholders, economic benefits and risks, cost data, availability of green materials and suppliers.	Ordinal. Five-point Likert scale: 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low
Q20.4	Technical aspects of green construction projects	Use of conventional methods and green building techniques, time required for design, lengthy approval process and specification, procurement delivery method, effective planning, scarcity of contractors with green building knowledge, early inclusion of project stakeholders.	Ordinal. Five-point Likert scale: 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low
Q20.5	Environmental aspects of green construction projects	Recycling of materials, water- efficiency, energy-saving techniques, waste management, site location, land ecology.	Ordinal. Five-point Likert scale: 5 = very high, 4=high, 3=moderate, 2=low, and 1= very low

3.8 Data Analysis Methods

The data used in the analysis was derived from the questionnaire. The collected data were entered into the Statistical Package for the Social Sciences (SPSS 28) software. The responses from the questionnaires were pre-coded as the respondents' names were not included. SPSS was identified as the most suitable analysis software since it makes use of descriptive statistics such as the mean and the standard deviation which are used in the research analysis to describe the variables measured. This study employs descriptive statistics, reliability (Cronbach's Alpha), Mean Item Score (MIS), and inferential statistics (Spearman's rho correlation) in analysing the data collected.

3.8.1 Mean item score (MIS)

In this study, a five-point Likert scale was used to determine the contribution of factors influencing sustainable development, sustainability performance, and delivery processes in green construction projects. The five-point Likert scale was based on the following rating scale: 1 = Very low importance, 2= Low importance, 3= Moderate, 4= High importance, 5= Very high importance. A combination of the Mean Item Score (MIS) and Standard Deviation (SD) values were utilized to rank the variables of interest based on the Likert scale rating. A MIS is a ratio of an individual item's summated score to the total number of respondents (Warmbrod, 2014). Equation 1 (Mukuka et al., 2014) presents the formula used to compute the mean item score:

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

Where: n_1 , n_2 , n_3 , n_4 , and n_5 represent the rating responses for very low, low, moderate, high, and very high importance respectively while N is the sample size.

The mean scores can be interpreted using the estimation degree as shown in Table 3.2 : Interpretation of Mean value on a five-point Likert scale (Abu-Baker et al., 2019).

Table 3. 2: Interpretation of Mean value on a five-point Likert scale

Mean value	Estimation degree
1.00 - 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very High

Source: (Abu-Baker et al., 2019).

The responses from the questionnaire based on the five-point scale were converted to MIS for each of the variables identified from the reviewed literature. The indices (mean item score) of each individual item were created and used to rank each item in relation to all the items constituting the scale. The factors were then ranked in terms of their relative importance as perceived by the respondents.

3.8.2 Test of the Hypothesis

Statistical procedures can be divided into parametric and non-parametric tests. Parametric tests are appropriate when the data is assumed to follow a normal distribution, continuous with equal variance, and have the same standard deviation (Kaur and Kumar, 2015). Conversely, non-parametric tests are applied to ordinal data (e.g., Likert scale) when a model consists of flexible parameters or ranked data (Mircioiu and Atkinson, 2017). To determine whether a parametric or non-parametric test is appropriate, several statistical tests are applied to assess whether the data is likely to follow a normal distribution (Knight and Ruddock, 2009). The test of normality is the first step that must be conducted before processing the data. These statistical tests used to test data normality include but are not limited to Kolmogorov-Smirnov test (sample size ≥ 50) and the Shapiro-Wilk test (sample size <50) (Mishra et al., 2019). The questionnaire survey comprised of nominal scale and the Likert scale ordinal data. This study employed non-parametric statistics such as Spearman's Rho coefficient to analyse the nominal and ordinal data.

3.8.2.1 Spearman's Rho coefficient

Spearman's Rho as a statistical tool assumes a monotonic relationship between variables to determine the strength of a correlation between two ordinal scale sets of data (Sedgwick, 2014). This statistical tool assumes that a sample of pairs is independent of one another. Spearman's rho utilizes Equation 2 to measure the strength of the monotonic relationship between two variables on the ordinal scale:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \dots \dots \dots \text{Equation 2}$$

Where: ρ = spearman's rank correlation coefficient; d_i = difference between the two ranks of each observation; and n = number of observations.

In this study, the factors obtained from the reviewed literature consist of five categories namely very high, high, moderate, low, and very low importance. The variables (factors existing in the project environment) are on ordinal scale hence Spearman's Rho test was applied for hypothesis testing to determine a single correlation coefficient between +1 and -1. Sedgwick (2014) provides a detailed explanation of the spearman rho correlation test. Sedgwick indicates that a correlation coefficient of zero is an indication of the absence of a relationship between the variables. A positive value denotes a positive correlation between the two variables. This means that as the value of one variable increases, so is the value of the other variable. A negative correlation signifies a negative relationship between variable whereby the value of one variable increases, as the value of the other variable decreases.

Statistical tools make use of a null hypothesis (H_0) and alternative hypothesis (H_1). The hypothesis system is as follows: H_0 = There is no relationship between two variables in a population. H_1 = There is a relationship between two variables in a population. To qualify the hypothesis system, hypothesis testing makes use of a 5% probability level ($p=0.05$) whereby:

- If $p > 0.05$: Null hypothesis is true.
- If $p < \text{or} = 0.05$: There is at least 95% probability that the null hypothesis is incorrect.

This means that a 5% probability level represents statically significant data and shows a true relationship. Therefore, a null hypothesis can be rejected, and alternative hypothesis (H_1) can be accepted.

3.9 Research Quality Criteria

The quality criteria must be considered at the design stage of the research, and this includes but not limited to the validity (internal, external, and construct), objectivity, and reliability of the data collection instruments (Bhattacharjee, 2012). The concepts of reliability and validity are crucial to the development of research instruments (Bannigan and Watson, 2009). Outcome variables used in quantitative research are developed from the reviewed literature hence the validity and reliability of measuring instruments used in quantitative research is crucial in determining the research quality. In quantitative research, the study is not influenced by the biases of the researcher. This is due to the objective approach adopted in quantitative research. In this research, objectivity was maintained by basing the findings on the collected data to answer the research question.

3.9.1 Validity

The concept of measuring the validity of research instruments can be broadly divided into construct, concept, and criterion validity (Heale and Twycross, 2015). However, to determine the causal relationship between variables and establish whether the research findings can be generalised to other contexts, one can also consider internal and external validity, respectively. Internal validity refers to the extent to which the research instrument measures the concept being studied and represent the truth in the study population (Andrade, 2018). External validity is defined as the extent to which the research findings can be generalized beyond the context of the study to a population, other people, organizations, contexts, or time (Bhattacharjee, 2012).

Criterion validity refers to the extent to which the study findings accurately predict an outcome from other instruments that measure the same variable (Heale and Twycross, 2015). Construct validity refers to the extent to which the research instrument measures the construct it is intended to measure. To ensure construct validity, various

sources of literature related to the study were used to determine relevant existing variables that will address the research objectives. In this study, validity was ensured by targeting a population of Green Star accredited professionals listed on the GBCSA database who are registered within the two categories namely 'new building and major refurbishments' and 'sustainable precincts'. These professionals are actively involved in the delivery processes of green construction projects and will therefore make valuable contribution to the study. Furthermore, Heale and Twycross define the final measure of validity which is content validity. Content validity focuses on whether the research instrument adequately represents all the content it was designed to measure. In this study, the questionnaire was checked by the research supervisor before the questionnaire was administered to ensure that it addresses the research question.

3.9.2 Reliability

Reliability is defined as the extent to which a research instrument would consistently yield the same results when it is repeated with a similar sample (Heale and Twycross, 2015). To ensure the reliability of the study the target population that was considered by the researcher includes the Green Star accredited professionals who have implemented green projects in the last five years. This is to ensure that substantial information on the relevant critical factors existing in the green construction project environment is obtained. To measure reliability of the Likert scales used in the questionnaire, Cronbach's Alpha – the most common measure of internal consistency (reliability) ranging from 0 to 1, where a coefficient of 0.7 or higher indicate greater reliability Knight and Ruddock (2009) – was used in testing the reliability of the Likert scales. In agreement, Taber (2018) also indicate that the acceptable internal consistency of the research instrument is considered acceptable when the Cronbach's Alpha coefficient is 0.7 or higher. Table 3.3 shows the internal consistency of the Likert scales used in the questionnaire that was measured on SPSS using Cronbach's Alpha. The computation of the Cronbach's Alpha coefficients for internal consistency of the research instrument are all greater than 0.7 except for the 'economic and social sustainability aspect' item which yields a coefficient of 0.693. This may be due to the missing data. However, the total scale alpha coefficient for the instrument is 0.940.

Therefore, the Cronbach's Alpha coefficients obtained suggests that the research instrument has a very high reliability.

Table 3. 3: Cronbach's Alpha reliability statistics

Question		No. of items	Cronbach's Alpha
Q15	Sustainable development in green construction projects	3	0.733
Q16.1	Environmental sustainability performance of green construction projects	9	0.782
Q16.2	Socio-economic sustainability performance of green construction projects	7	0.890
Q20.1	Knowledge and awareness of green construction projects	7	0.769
Q20.2	Governmental policies and regulations	6	0.700
Q20.3	Social and economic aspects of green construction projects	9	0.693
Q20.4	Technical aspects of green construction projects	12	0.770
Q20.5	Environmental aspects of green construction projects	7	0.730
Total scale		60	0.940

3.10 Ethical Considerations

Outlined below are the anticipated ethical issues associated with using the online survey for data collection and how these issues will be handled:

3.10.1 Ethical clearance

Ethical clearance was obtained from the University of Cape Town (refer to Appendix A) prior to conducting the questionnaire survey.

3.10.2 Anonymity and Confidentiality

The prospective participants were ensured that the questionnaire data would be kept confidential. The questionnaires were completed on Microsoft Forms and responses. The researcher maintained their anonymity throughout the study by ensuring that responses are coded and only a number will identify a participant.

3.10.3 Permission

An information sheet and consent documents were issued to participants to ensure that they are aware of the requirements of the study prior to participation. A survey link was sent to participants that had given informed consent. The consent document

informed the participants about the nature of the study, and how voluntary participation is associated with no negative consequence if the participant decides to withdraw or not participate, as well as how there are no risks and no benefits involved in the study. Feedback was given to the respondents that expressed interest in the summary of the results.

3.11 Chapter Summary

This chapter provided an overview of the research method used to carry out the study to address the research question. The study adopted the quantitative research method using questionnaire surveys as a primary method of data collection. The researcher utilized a cross-sectional research design to make inferences about relationships between variables involved in the research. The interpretation of the data collected in this study will be detailed in the next chapter. The ethical issues considered in the research to ensure that the study was conducted in a manner that does not cause harm to participants – including anonymity and consent to voluntary participation in the study – were outlined in the chapter.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS and DISCUSSION OF FINDINGS

4.1 Introduction

In this chapter, research findings obtained from the questionnaire survey responses are presented, analysed, and discussed.

4.2 Data Presentation

This section presents the data collected from the questionnaire survey that was conducted among the Green Star SA accredited professionals in Western Cape and Guateng region of South Africa. The questionnaire survey comprises of two sections. The first section sought the background profile of the participants which comprises of the following: respondent's demographic and organizational profile, Green Star SA accredited certification program, and methods of continuing professional development. The second section explored the factors influencing sustainable development, sustainability performance, and delivery processes of green construction projects. The green construction projects are completed in the last five years to ensure that the data obtained is relevant to current green construction trends. Data collected was analysed using the statistical tools discussed in section 3.8.

4.2.1 Demographic characteristics

This section presents the demographic characteristics of the respondents such as gender, age, professional background, and education.

Question 1 sought to find out the gender distribution of the respondents. Table 4. 1: Gender of respondents shows that 42% of the respondents are females and 58% of are males. This question sought to determine gender distribution in the implementation of green construction projects. The data suggests that the green building sector is male dominated . However, the percentage of females involved is starting to develop, suggesting that females are becoming more involved in green construction.

Table 4. 1: Gender of respondents

Gender	Frequency	Percentage
Female	14	42%
Male	19	58%
Total	33	100%

Question 2 sought to find out the age of the respondents. The purpose of this question was to determine the age groups of professionals involved in green buildings. Green building is an emerging concept in the construction industry, and a representation of all age groups is beneficial for the growth of green buildings projects in terms of years of experience in the field and knowledge transmission. The results of this enquiry is presented in Table 4.2. Based on the responses, only one respondent represented the under 25 group or 3% of the sample while 18% of the respondents fall within the age group of 26-30 years. Most of the respondents are between the 31-35 years age bracket representing 24% of the sample, while 15%, 12%, 15%, 12% of the respondents are within the 36-40, 41-45, 46-50 years and above 50 years age group respectively. The findings suggest that young professionals between the 26-35 years age bracket are mostly involved in the green building sector. Notwithstanding the fact that there is a good representation of professionals above the 35 years age bracket. The findings signify that green building is an emerging sector and young professionals are becoming more involved in its development.

Table 4. 2: Age of respondents

Age (Years)	Frequency	Percentage
Under 25	1	3%
26-30	6	18%
31-35	8	24%
36-40	5	15%
41-45	4	12%
46-50	5	15%
Above 50	4	12%
Total	33	100%

Question 3 of the survey sought to know the professional background of the respondents. The purpose of this question was to determine the range of built environment professionals who are involved in green buildings implementation. Table 4. 3: Professional background of respondents. presents the findings of this enquiry. Sustainability consultants account for 36% of the population. The survey indicates that Architects and Engineers account for 21% of the sample for each profession. Other notable professions are Quantity Surveyors and Construction Projects Managers, each accounting for 3% of the respondents. Respondents who selected ‘other’ represent 9% of the sample and these professions include property asset manager, and utility manager while the remaining 6% are unspecified. Data shows a wide range of professions who are sustainability consultants represent a larger group of the respondents, accounting for 36%. This signifies that the green building sector is populated by professionals who are employed full-time to solely improve the sustainability of buildings. Architects and Engineers also play a huge role in the implementation of green buildings.

Table 4. 3: Professional background of respondents

Profession	Frequency	Percentage
Sustainability Consultant	12	36%
Architect	7	21%
Engineer	7	21%
Unspecified	3	9%
Other	2	6%
Quantity Surveyor	1	3%
Construction Project Manager	1	3%
Total	33	100%

Question 4 of the survey sought to know the academic background of the respondents to determine the education level of participants and obtain an indication of the academic background of professionals involved in green building projects. Table 4. 4: Academic background of respondents. shows that most of the respondents are highly educated as the professionals who hold a master’s degree account for 39% of the sample. This is followed by honours degree and bachelor’s degree, accounting for

24% for each category. Professionals who hold a diploma/advanced diploma account for 6% of the respondents. The minority of the respondents hold a higher certificate and doctoral degree, each accounting for 3% of the respondents. All of the respondents are knowledgeable and will provide valid information.

Table 4. 4: Academic background of respondents

Qualification	Frequency	Percentage
Higher Certificate	1	3%
Diploma/Advanced Diploma	2	6%
Bachelor's degree	8	24%
Honours degree	8	24%
Master's degree	13	39%
Doctoral degree	1	3%
Total	33	100%

Question 6 of the survey sought to know the number of years of experience of the respondents in the construction industry and green buildings delivery. The purpose of this question was to quantify the amount of work experience of the respondents as this may affect the quality of the responses.

Figure 4.1 shows that 18% of the respondents have professional experience of less than 5 years in each of the construction industry and green buildings categories. Professionals with years of experience between 5-10 years in the construction industry and green buildings account for 33% and 39% of the sample respectively. Most of the respondents fall within the range of 5-10 years of experience in green construction projects. This signifies that the implementation of green construction projects in South Africa is an emerging concept. Professionals with years of experience between 11-15 years account for 15% and 21% for each of the construction industry and green buildings categories. Categories which represent 16-20 years of experience in the construction industry and green buildings account for 15% and 3% respectively. Furthermore, professionals with years of experience above 20 years account for 18% for each of the construction industry and green buildings categories. Data shows that 82% of the respondents have more than five years of experience in the construction industry and green buildings. The work experience in the construction industry and in

green buildings coupled with the level of academic background of respondents show that the respondents have sufficient knowledge of the built environment.

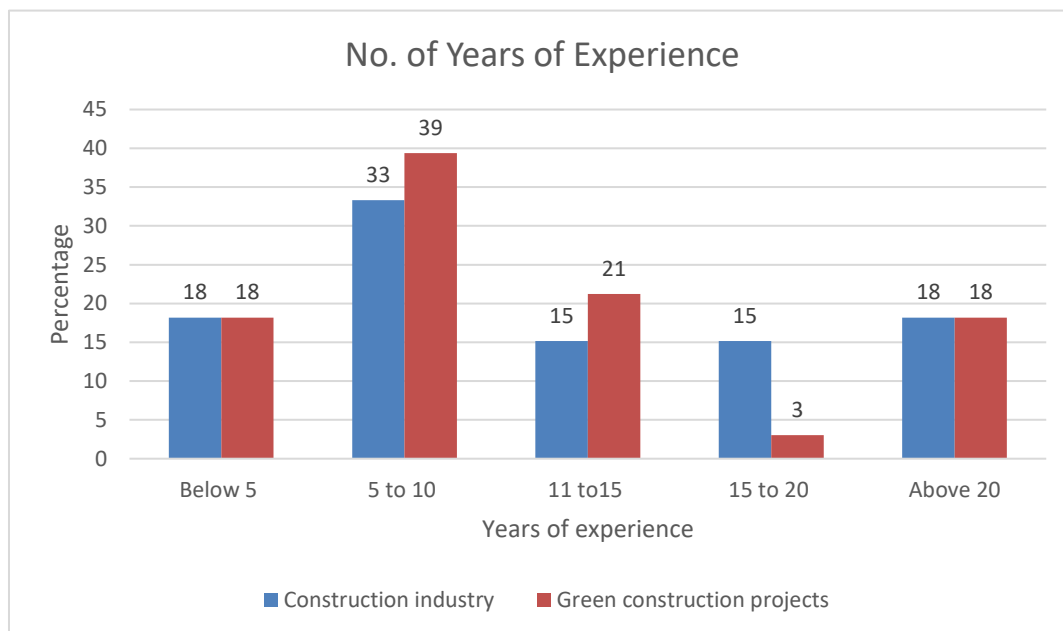


Figure 4. 1: No. of years of experience of the respondents in the construction industry and green buildings

4.2.2 Profile of the respondents organizations

Question 5 of the survey sought to find the profile of the organizations the respondents are affiliated. This question sought to determine which organization is mostly involved in green building projects as this will give an indication of the building sectors in which the respondents are involved in. The public and the private sector are both adopting green standards and practices in the construction projects. The results presented in Figure 4. 2: Organizational profile of the respondents reveal that 21% of the respondents are employed in the public sector account while 79% are employed in the private sector. The findings suggest that the private sector is more likely to develop green buildings than the public sector.

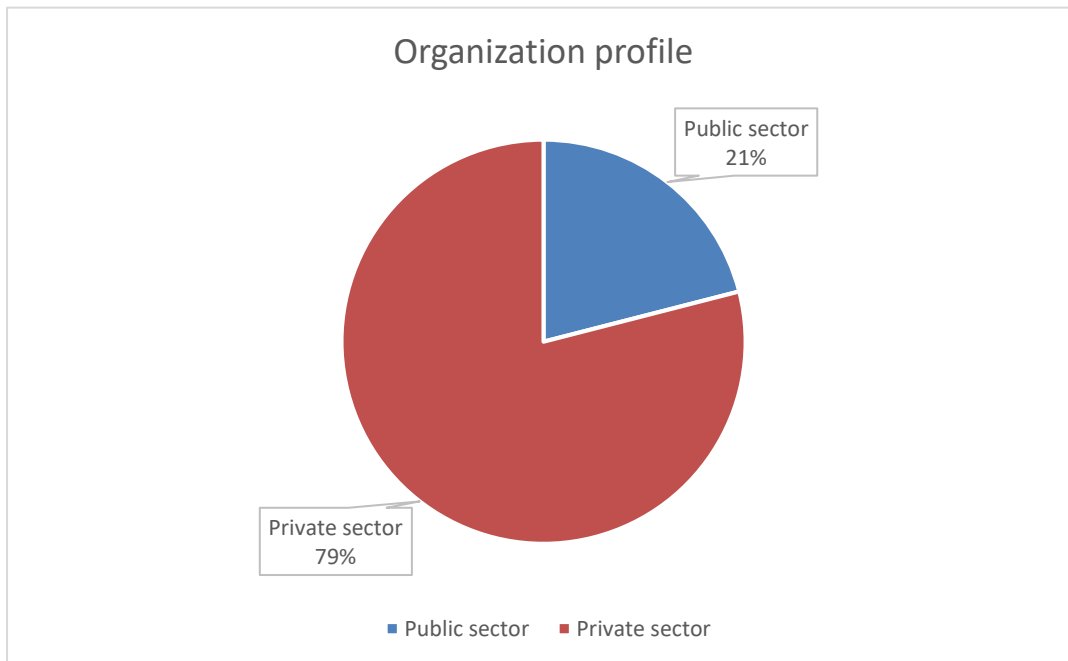


Figure 4. 2: Organizational profile of the respondents

Question 7 of the survey sought to establish the specific building sector in which the respondents work. The results of this enquiry is presented in Figure 4. 3: Building sector specific to Green Star accredited professionals. It can be seen from Figure 4.3 that all respondents indicated that they are involved in more than one building sector. While 76% of the respondents indicated their involvement in the office building sector, followed by 55% of respondents involved in multi-unit residential buildings. The educational, public, and retail centre buildings account for 48%, 45%, and 42% respectively. The results also show that 18% of the respondents who selected 'other' are involved in the hospital infrastructure, the hospitality industry, and industrial building sectors. This indicates that the respondents are knowledgeable and have experience in various building sectors. The GBCSA Green Star rating tool is applicable to various building sectors. Projects are different; therefore an insight into different building sectors will yield trustworthy results. The findings also show that other buildings such as hospital infrastructure, hospitality industry, and industrial buildings are adopting green standards and practices.

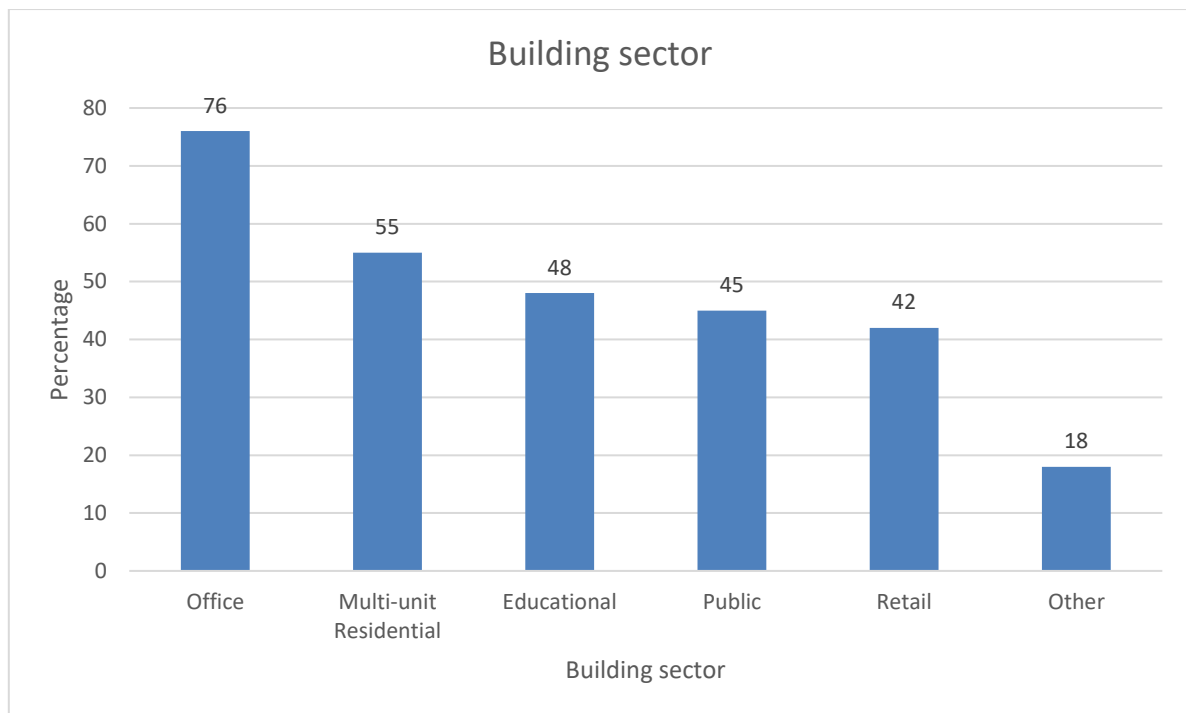


Figure 4. 3: Building sector specific to Green Star accredited professionals

4.2.3 Green Star Certification

The questionnaire survey is focused on the delivery of green construction projects. Hence, the population of interest is actively involved in the planning, design, construction, and procurement phases of green construction projects. Question 8 sought to find out if each respondent is a Green Star SA-Accredited Professional. All respondents confirmed that they are registered as Green Star accredited professionals and specified the year of their registration. The Green Star rating tools were introduced in 2009 in South Africa. The question sought to establish the date of initial registration of the respondents as Green Star accredited professionals. Figure 4. 4: Year of Green Star certification registration shows that 6% of the respondents first registered as Green Star accredited professionals from the year 2012 while 6% of the respondents were registered in 2013. There was an exponential increase in the number of certifications in 2014 amongst the respondents with 12% of the respondents registered as accredited professionals. In 2016 and 2020, the number of certifications seem to have dropped to 3%. The number of certifications in 2017, 2018 and 2021 increased to 6% each year. The collected data shows slow growth in the number of Green Star accredited professional certifications between the years 2012 and 2021. An abrupt

growth in the number of these certifications appeared in 2022 when 28% of the respondents were registered representing a high percentage of the sample. However, these respondents were already involved in green construction projects prior to 2022.

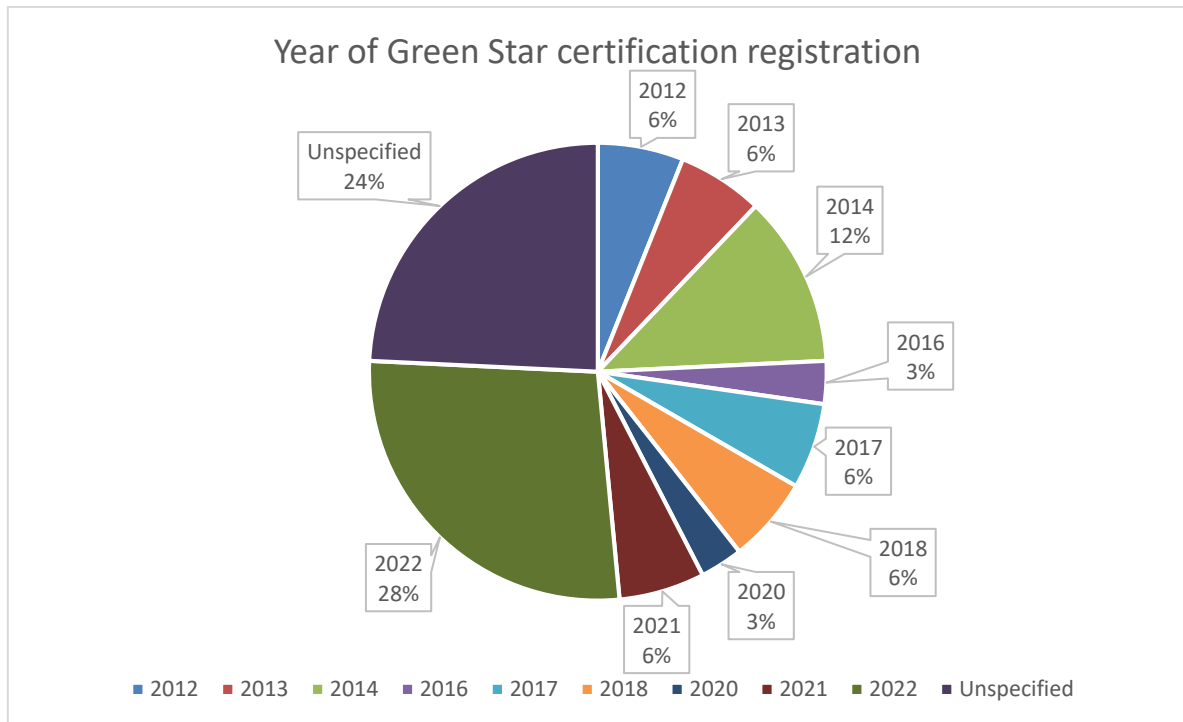


Figure 4. 4: Year of Green Star certification registration

The second part of question 8 sought to establish the Green Star accredited programmes in which the respondents are registered. Figure 4. 5: Green star certification accredited programme shows the target sample comprises of Green Star accredited professionals who are currently registered as ‘new building and major refurbishments’ and ‘sustainable precinct Green Star accredited professionals. The data shows that 78% of the respondents are registered with the new buildings and refurbishment rating tool, 3% are registered with the Sustainable Precincts rating tool, and 5% are registered with both rating tools while 15% were unspecified.

The new building Green Star rating tool allows for design and as-built certifications. This certification focuses on the design, construction, and procurement stages of a building. The design aspects involve tender drawings and specifications, while the as-built is based on records of as-built drawing and commissioning. The sustainable precinct Green Star rating tool is different from the other rating tools as it is concerned

with site wide issues such as site selection, site analysis, and site layout. The site planning process involves the plan for the development (brownfield/redevelopment, campus/business park, urban infill/renewal and greenfield) and is related to the environmental performance of the planning, design, and construction stages of precincts (GBCSA, 2022c).

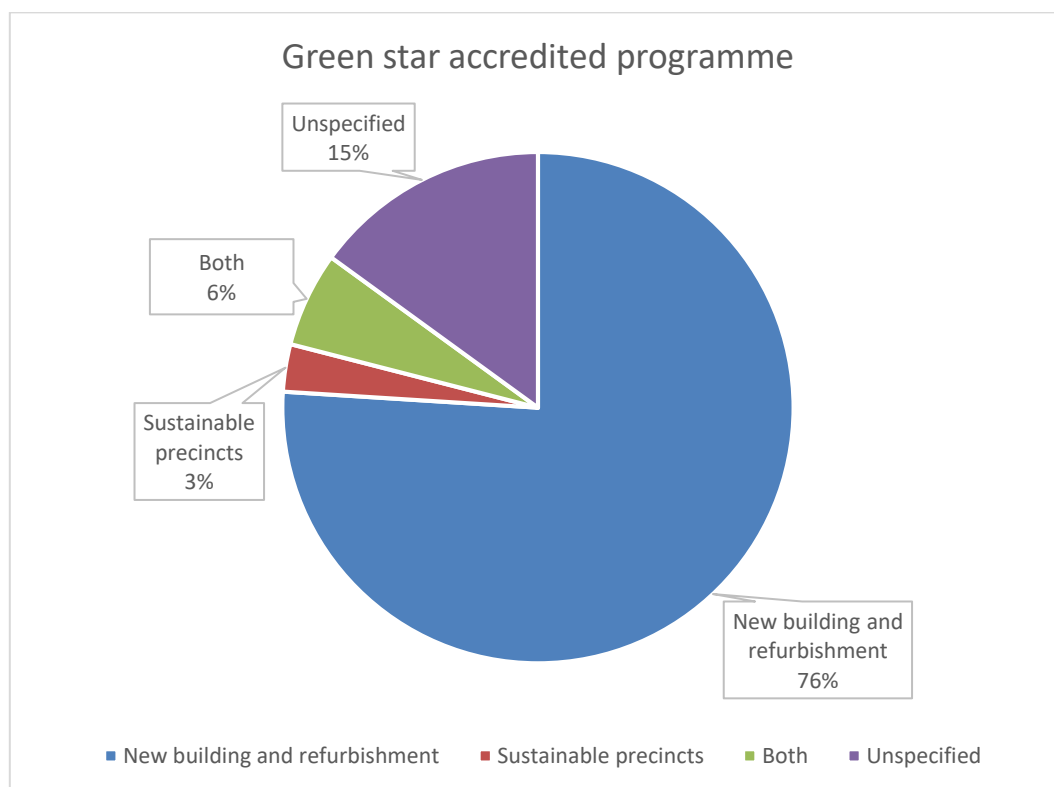


Figure 4. 5: Green star certification accredited programme for green construction projects

Question 9 of the questionnaire sought to determine the number of green building projects implemented by the respondents and how many of those projects qualified for a Green Star SA certification. This is to establish the adaptation capacity of green buildings and if buildings are Green Star certified. Similarly, **question 10** sought to establish how many of the Green Star certified projects qualified for the socio-economic impact category. Figure 4. 6: Delivery of green construction projects shows that 60% of the respondents have implemented more than three green construction projects. Most of the respondents have developed more than 15 green projects accounting for 26% of the sample. While 18% of the projects are not green certified. However, 79% of these projects have been green certified with 3% of the projects in the process of obtaining the Green Star certification.

In relation to the socio-economic impact category, 67% of the projects have not registered with this category and the 30% of the projects registered with the socio-economic impact category are only within the range of 1-5 projects while only 3% of the projects are in the process of registering with the process. The survey outcome shows that the rating of the environmental sustainability performance in green construction projects is gaining traction. However, there is a slow growth in the inclusion of the socio-economic impact category in projects.

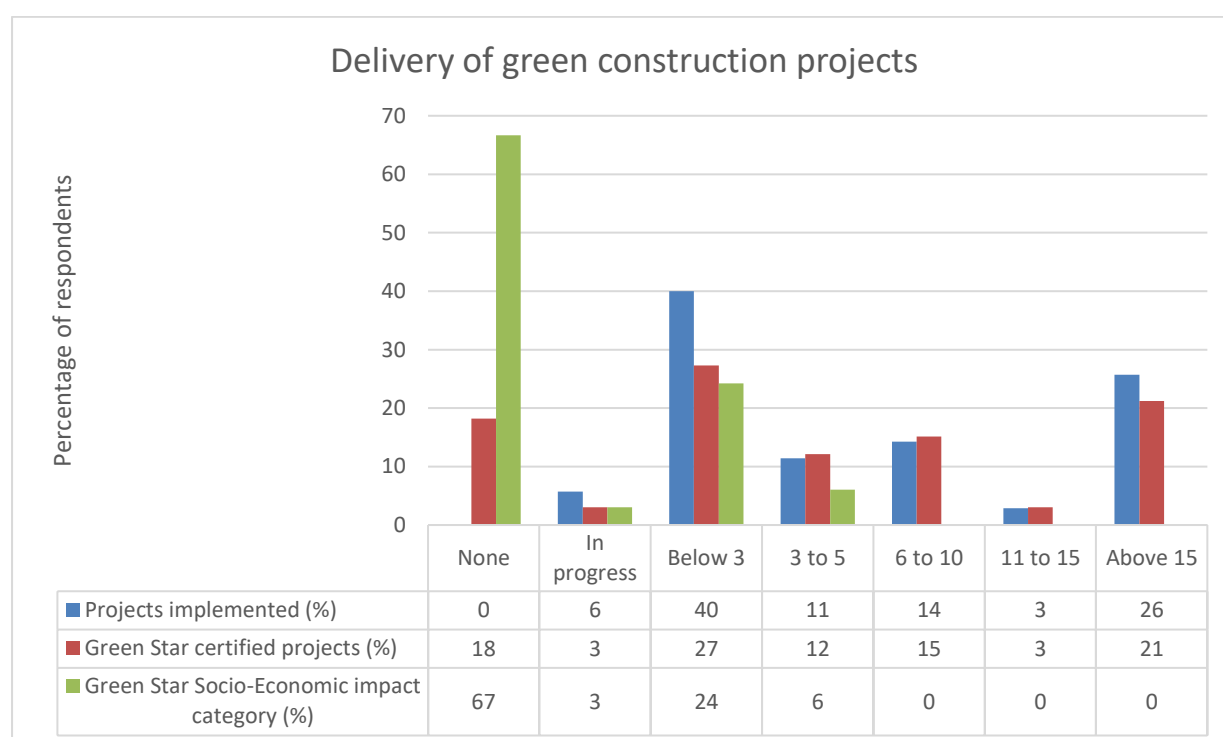


Figure 4. 6: Delivery of green construction projects

Question 11 of the survey sought to establish the methods through which the respondents improved their green construction experience and knowledge over the years. All respondents selected more than one method. Figure 4. 7: Professional development in green construction projects shows that the GBCSA courses/conference attendance is the most popular method of professional development among the Green Star accredited professionals as 85% of the respondents selected this method. This is followed by the involvement in green construction projects where 79% of the respondents selected this method. The GBCSA conference promote the adoption of green buildings in South Africa and in Africa.

The conference provides exposure to the green building industry by sharing insights into the achievements of the previous projects, current and future work. 70% of the respondents selected organizational workshops, 64% of the respondents selected further education and training. Professionals are starting to further their studies to seek knowledge and innovative ways to better the green building industry. While 61% of the respondents selected online publications and articles as a professional development method which indicates an interest of professionals in terms of being aware of the progress in the green building industry. More than 50% of respondents selected each method and that shows that the selected sample has adequate technical knowledge in green construction projects which will benefit the research study. Their level of involvement in green construction projects indicates that the respondents have sufficient experience to contribute meaningfully to the questionnaire survey.

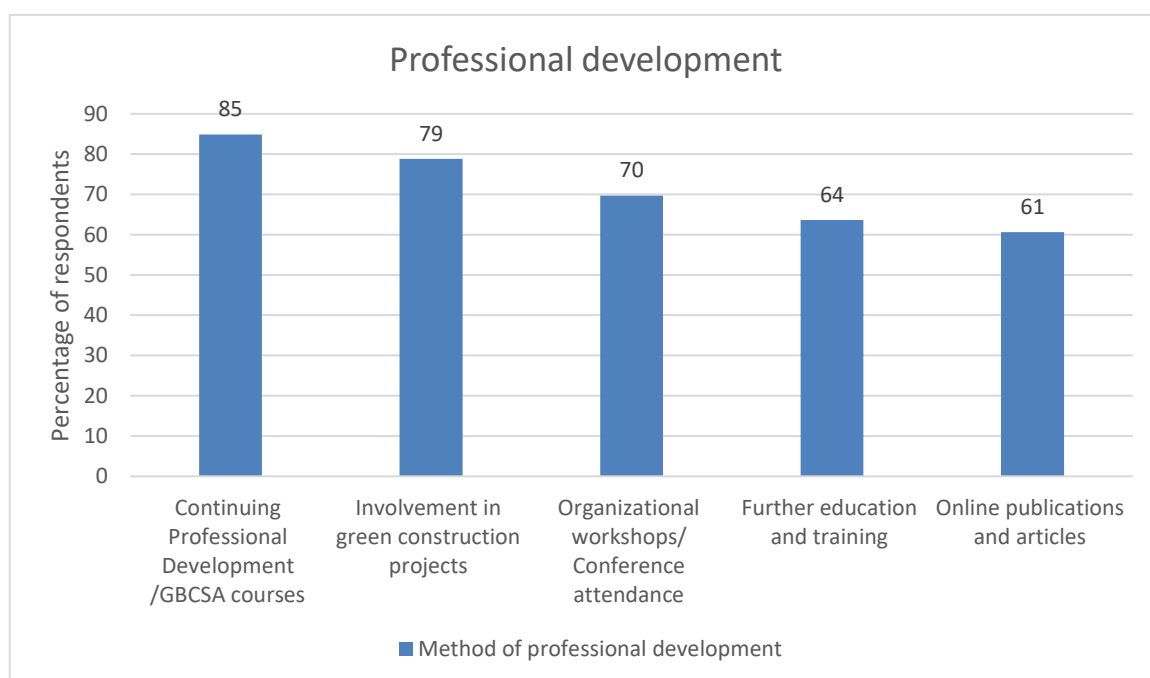


Figure 4. 7: Professional development in green construction projects

4.2.4 Involvement in green construction projects

Question 12 sought to establish when these identified projects were completed. The summary of the responses is presented in Figure 4. 8: Year of completion of green construction projects. Figure 4.8 shows that 36% of the projects were completed in 2022 and the least of the projects (3%) were completed in 2017. While 12% of green

construction projects were completed in 2018, 9% of the projects were completed in 2019, 6% of the projects were completed in 2020, indicating a decline from the previous year. In 2021, the number of projects completed started to rise with 18% of the projects completed. The survey outcome shows that 9% of the projects are in progress while 6% was unspecified.

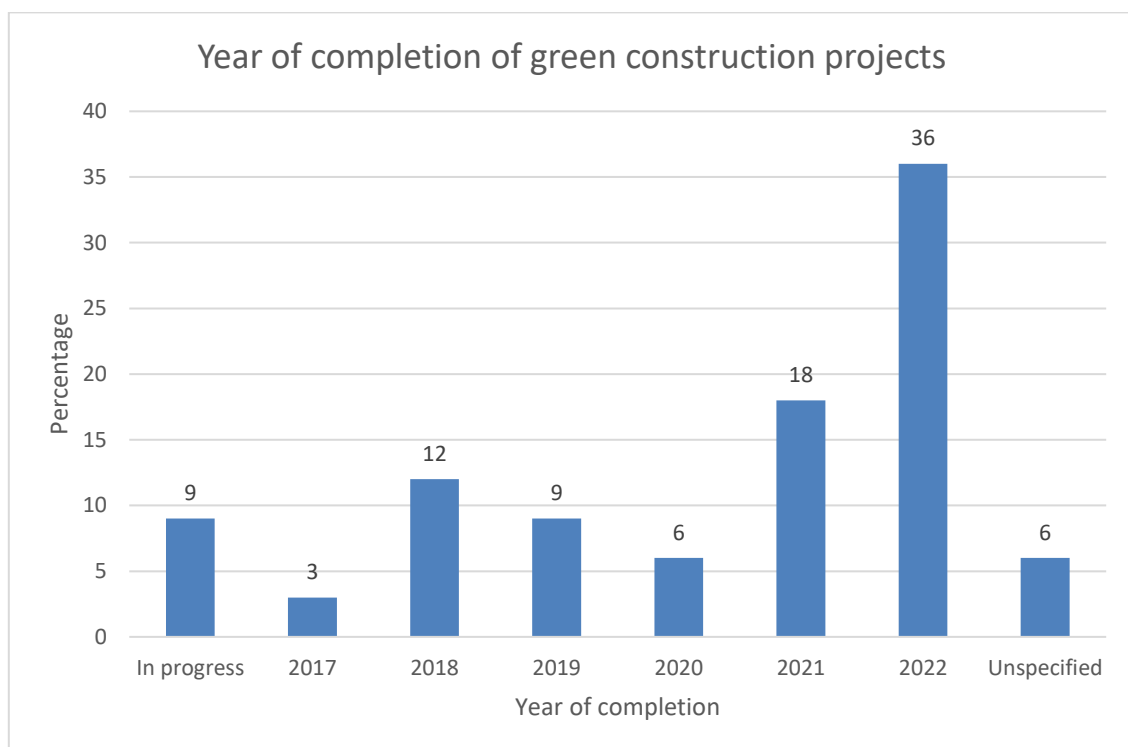


Figure 4. 8: Year of completion of green construction projects

Question 13 of the survey sought to know the location of the green construction project. The purpose of this was to gain an understanding of where these green construction projects are developed. Figure 4. 9: Location of the individual green construction projects shows that most of these green construction projects reported were implemented in the Gauteng province, accounting for 48% of the total projects conducted. These projects were in Rosebank, Sandton, Midrand, Centurion, and Pretoria. This is followed by 36% of projects that were implemented in the Western Cape Province only in Cape Town. While, 12% of the projects were selected as 'other' are located in Limpopo, Northwest, KwaZulu Natal, and Botswana and 3% of the projects were unspecified.

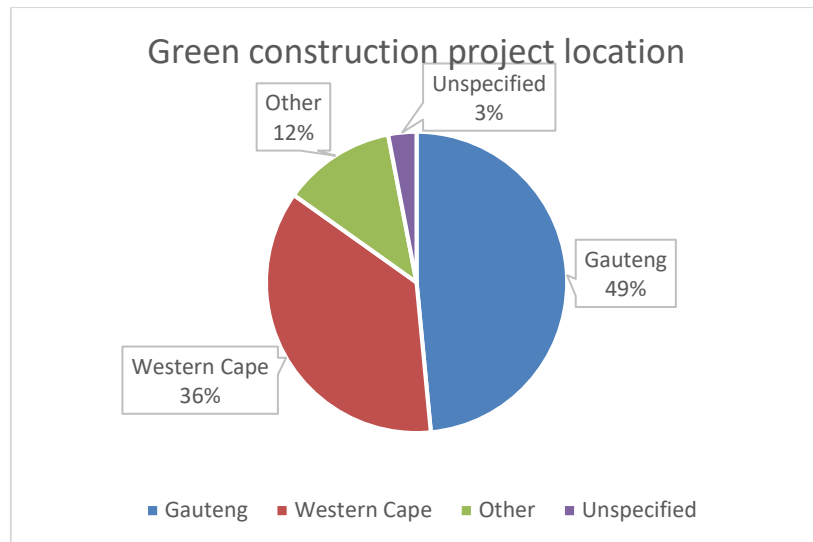


Figure 4. 9: Location of the individual green construction projects

Question 14 of the survey sought to establish the level of Green Star rating of the projects implemented by the respondents. Certification of the Green Star rating tools are 4, 5, and 6-Stars where 4 Stars represents 'best practice', 5 Stars represents 'South African excellence', and 6 Stars represents 'world leadership' (GBCSA, 2017). Figure 4. 10: Green star rating of projects implemented shows that 42% of the projects which represents the majority, was awarded a 6-star rating, 30% were awarded a 4-star rating and 18% were awarded a 5-star rating, 6% of the projects are in progress and only 3% are unspecified.

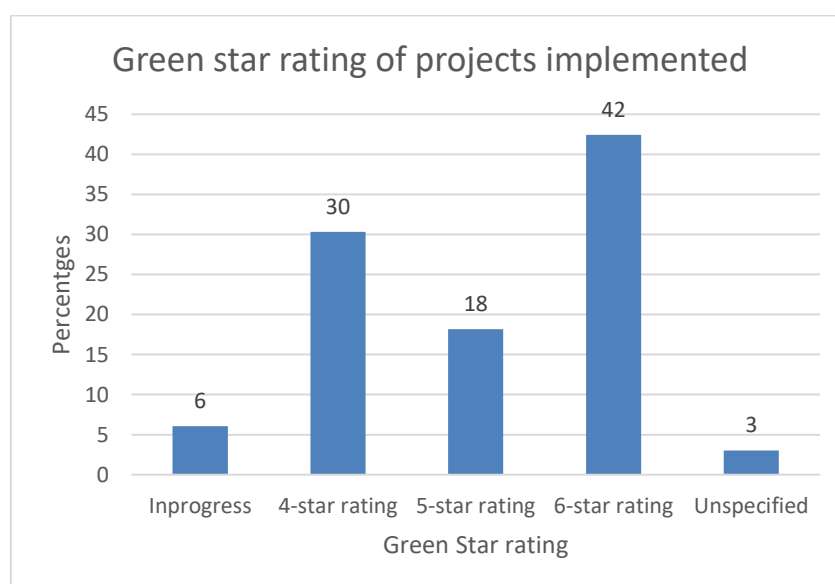


Figure 4. 10: Green star rating of projects implemented

4.2.5 Sustainable development of green construction projects.

Question 15 of the survey sought to evaluate the respondents perceptions of the extent to which the developed building projects meet the present needs without compromising the needs of future generations. Table 4.5 shows the ranking of the perception of respondents. The survey outcome shows that from a high ranking perspective, environmental protection factor was ranked first (MIS= 4.03), followed by economic growth (MIS=3.55), and social equity (MIS=3.12).

Table 4. 5: Green construction project contribution to sustainable development (SD)

SD	VL	L	M	H	VH	Total	MIS	Std. deviation	Ranking
Environmental	0	1	6	17	9	33	4.03	0.770	1
Economic	0	2	14	14	3	33	3.55	0.754	2
Social	4	2	14	8	5	33	3.12	0.838	3

Where: SD = Sustainable Development; VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

4.2.6 Sustainability performance of green construction projects.

Question 16 sought to evaluate the extent to which the building projects implemented achieve the sustainability performance indicators. The GBCSA environmental sustainability performance category has nine factors that are taken into consideration to certify a building. Table 4.6 shows these environmental sustainability factors in order of high importance as perceived by the respondents: indoor environment quality (MIS=4.27), energy efficiency (MIS=4.12), water efficiency (MIS=4.09), management of building systems (MIS=4.09), greenhouse emissions (MIS=3.97), transport (MIS=3.91), innovation (MIS=3.69), land use and ecology (MIS=3.44), and material reuse and recycling (MIS=3.41). The optional socio-economic impact category consists of seven factors which are ranked by respondents in Table 4.6 Table 4. 6: Sustainability performance sustainability indicators for green construction project in order of importance as: health and safety (MIS=3.52), skills development and training (MIS=3.45), Implementation of Broad-Based Black Economic Empowerment (MIS=3.28), employment creation (MIS=3.22), economic opportunity (MIS=3.13), community benefit (MIS=3.07), and creation of mixed income housing options – multi-unit residential (MIS=1.58).

Table 4. 6: Sustainability performance sustainability indicators for green construction project

Environmental sustainability performance	1= Very low	2= Low	3= Moderate	4= High	5= Very High	N	MIS	Std. deviation	Ranking
Indoor environment quality	0	0	2	20	11	33	4.27	0.574	1
Energy Consumption/Demand	0	1	7	12	13	33	4.12	0.857	2
Water Consumption/Demand	0	0	7	16	10	33	4.09	0.723	3
Management (maintenance and operation of building systems)	0	1	4	20	8	33	4.06	0.704	4
Reduction of greenhouse gas emissions	0	2	5	17	8	32	3.97	0.82204	5
Building location near public mass transport networks	1	3	5	12	11	32	3.91	1.088	6
Implementation of innovative technologies, designs, and processes	3	2	8	8	11	32	3.69	1.281	7
Land use and ecology	1	6	7	14	4	32	3.44	1.045	8
Reuse and recycling of construction materials.	1	6	9	11	5	32	3.41	1.073	9
Socio-economic impact category									
Improved health and safety for construction workers	2	1	12	11	5	31	3.52	1.029	1
Skills development and training	2	2	12	10	5	31	3.45	1.060	2
Implementation of Broad-Based Black Economic Empowerment	2	6	11	7	6	32	3.28	1.170	3
Employment creation	2	3	15	10	2	32	3.22	0.941	4
Economic opportunity	2	4	14	10	1	31	3.13	0.922	5
Community benefit	2	7	12	5	4	30	3.07	1.112	6
Creation of mixed income housing (Multi Unit Residential)	16	3	4	1	0	24	1.58	0.929	7

4.2.7 Construction and procurement delivery methods

Question 17 of the survey sought to know the construction delivery methods used by the respondents in the projects of interest. Figure 4. 11: Construction method used for the green construction projects shows that most of the respondents used the in-situ on site construction method, accounting for 52% of the sample. This is followed by 33% of the respondents who used hybrid and 6% who used the precast off-site method. Only 9% of the sample was unspecified.

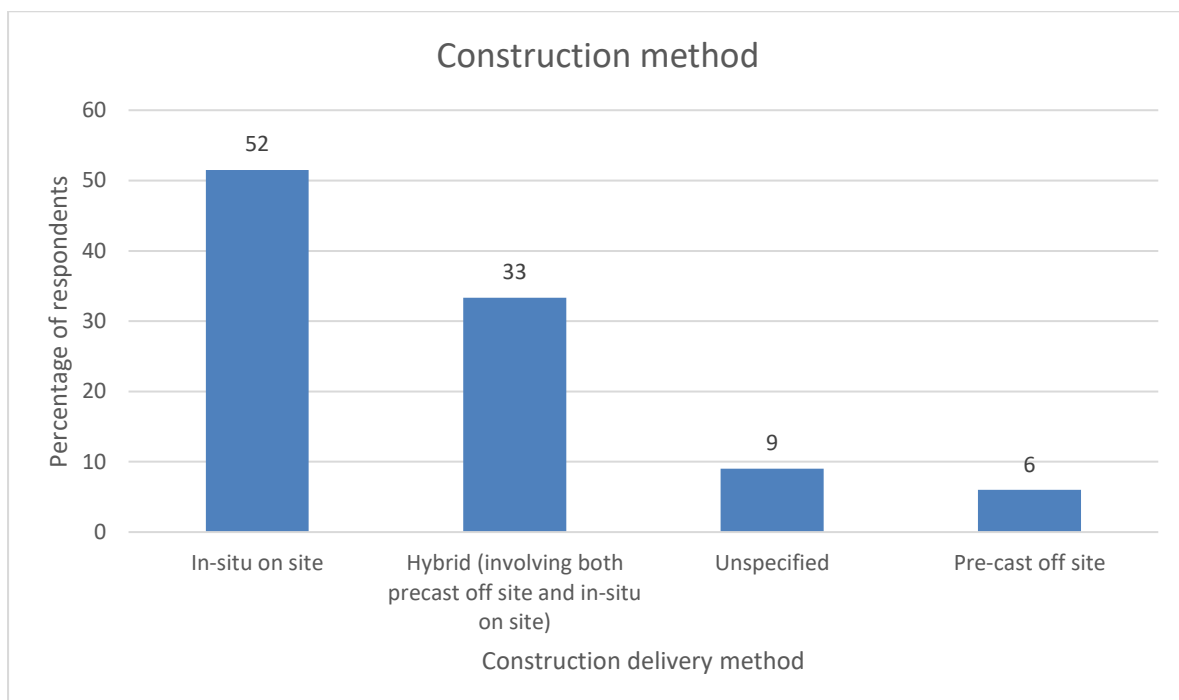


Figure 4. 11: Construction method used for the green construction projects

Question 18 sought to know the procurement method used by the respondents in the identified projects. Figure 4. 12: Procurement delivery method used for the green construction projects shows that most of the respondents used the design-bid-build (traditional method) accounting for 76% of the sample, followed by 21% of the respondents who used the design-build method and 3% who used the construction management at risk method. While 14% of the sample was unspecified.

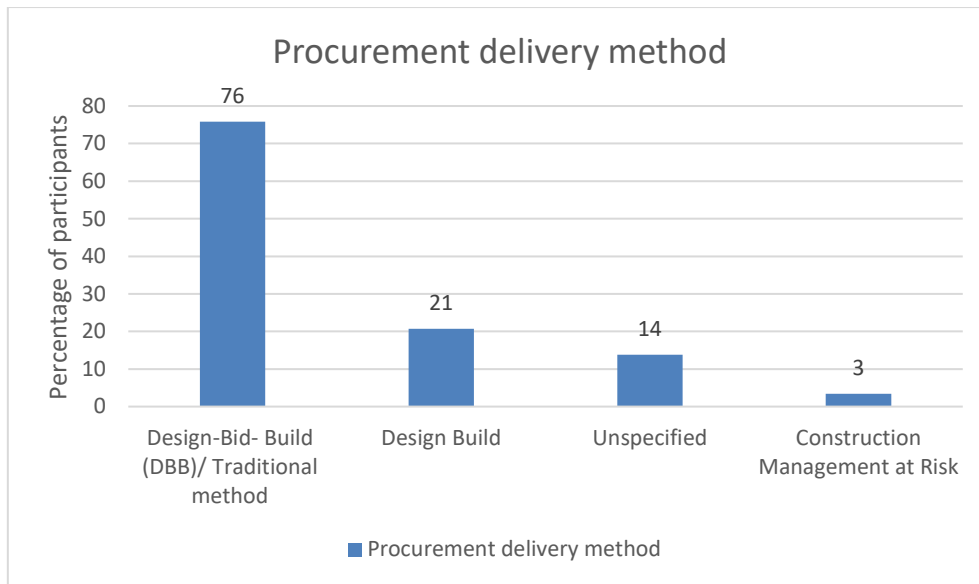


Figure 4. 12: Procurement delivery method used for the green construction projects

Question 19 sought to establish whether the procurement delivery method selected above was modified to accommodate the green building project. Figure 4. 13: Modification of the procurement delivery method used for the green construction projects shows that 46% of the respondents indicated 'no', 18% of the respondents indicated 'yes', while 26% of the respondents did not specify whether the procurement delivery method was modified. Most of the respondents stated that the procurement delivery method was not modified.

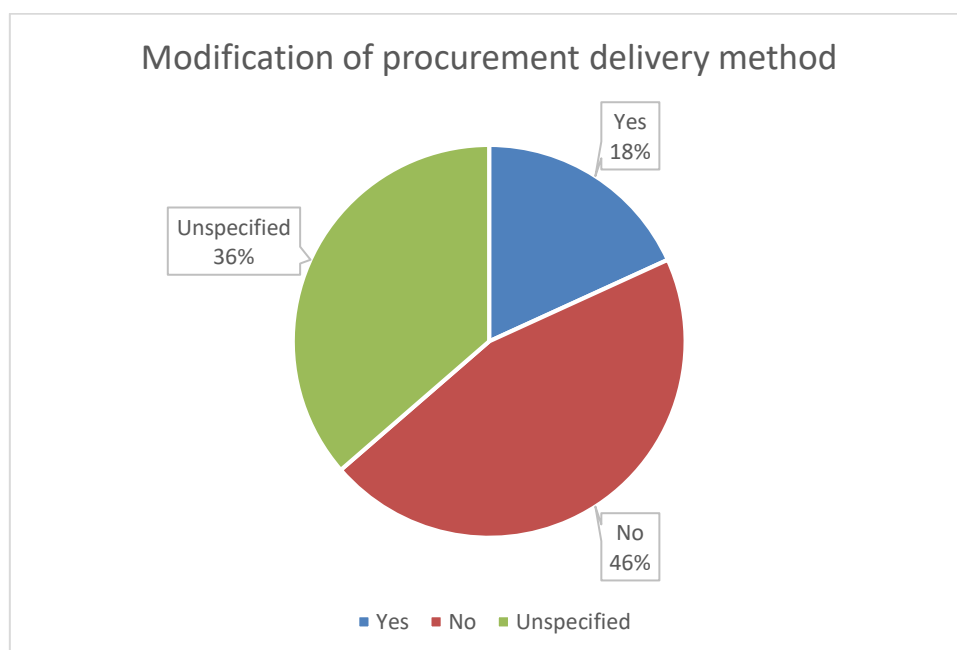


Figure 4. 13: Modification of the procurement delivery method used for the green construction projects

4.2.8 Factors affecting the sustainable development, performance, and delivery processes of green construction projects

This section sought to establish the factors influencing the sustainable development, performance, and delivery processes of green construction projects as perceived by the respondents. A list of factors existing in the green project environment was identified from the reviewed literature and was included in a questionnaire survey sent to Green Star-Accredited Professionals. Respondents were asked to choose any green construction project they are conversant with that was implemented in the last 5 years. Knowledge of the green construction project implemented was required in answering the questions in the second section of the survey. The responses were measured using a five-point scale of 1 to 5 where; 5= Very High, 4= Low, 3= Moderate, 2=Low, and 1= Very Low.

4.2.8.1 Measurement of knowledge and awareness-related factors

Question 20.1 sought the respondents' perception of the knowledge and awareness-related factors influencing sustainable development, performance, and delivery processes of construction projects in South Africa. Table 4. 7: Knowledge and awareness-related factors influencing the sustainable development, performance, and delivery process of green construction projects shows that from a ranking perspective, expressed interest, and demand from clients (MIS=4.06) was ranked first, followed by Professional knowledge and experience/skills in green buildings (client, designer, and contractor) was ranked second (MIS=3.97), Public awareness regarding benefits of using green technologies was ranked third (MIS=3.66), Knowledge of software to prepare green building designs was ranked fourth (MIS=3.60), Availability of empirically proven cost data for green buildings was ranked fifth (MIS=3.59), Availability of research data on sustainable building methods and green technologies was ranked sixth (MIS=3.58); and lastly ranked is public concerns on the quality and performance of green materials (MIS=2.68).

Table 4. 7: Knowledge and awareness-related factors influencing the sustainable development, performance, and delivery process of green construction projects

Knowledge and awareness-related factors	1= VL	2= L	3= M	4= H	5= VH	No.	MIS	Std. deviation	Ranking
Expressed interest, and demand.	0	2	3	18	9	32	4.06	0.801	1
Professional knowledge and experience/skills in green buildings (client, designer, and contractor).	1	2	5	14	11	33	3.97	1.015	2
Public awareness regarding benefits of using green technologies.	0	3	12	10	7	32	3.66	0.937	3
Knowledge of software to prepare green building designs (e.g., Life-Cycle Analysis tools, Building Information Modelling (BIM)).	1	7	6	5	11	30	3.60	1.303	4
Availability of research data on sustainable building methods and green technologies.	0	2	14	13	4	33	3.58	0.792	6
Inclusion of education/training for operation and maintenance staff, and end-user.	3	2	10	10	6	31	3.45	1.179	5
Public concerns on the quality and performance of green materials.	6	6	12	6	1	31	2.68	1.107	7

Where: VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

4.2.8.2 Measurement of governmental-related factors

Question 20.2 focused on the rating of the respondents' perception of the governmental-related factors influencing sustainable development, performance, and delivery processes of construction projects in South Africa. Table 4. 8: Governmental-related factors influencing the sustainable development, performance, and delivery process of green construction projects shows that the enforcement of green building codes and regulations (MIS=4.12). Complexity of government legislative procedures and requirements of submission documentation was ranked second (MIS=3.16). Collaboration between developers and transport planning authorities was ranked third (MIS=2.41). Delay in in approval of green building projects by local authorities was ranked fourth (MIS=2.10). Funding for research and the

implementation of green buildings was ranked fifth (MIS=2.00), and the least ranked was governmental support or incentives (MIS=1.78).

Table 4. 8: Governmental-related factors influencing the sustainable development, performance, and delivery process of green construction projects

Governmental-related factors	1= VL	2= L	3= M	4= H	5= VH	No.	MIS	Std. deviation	Ranking
Green building codes and regulations.	0	1	7	12	13	33	4.12	0.857	1
Complexity of government legislative procedures and documents required.	2	7	11	8	4	32	3.16	1.110	2
Collaboration between developers and transport planning authorities.	10	5	7	6	1	29	2.41	1.268	3
Delay in approval of green building projects by local authorities.	10	9	9	2	0	30	2.10	0.960	4
Funding for research and the implementation of green buildings.	12	11	6	3	0	32	2.00	0.984	5
Governmental support / incentives	14	13	3	2	0	32	1.78	0.870	6

Where: VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

4.2.8.3 Economic and financial-related factors

Question 20.3 focused on the rating of the respondents' perception of the economic and financial-related factors influencing sustainable development, performance, and delivery processes of construction projects in South Africa. Table 4. 9: Economic and financial-related factors influencing the sustainable development, performance, and delivery process of green construction projects shows that the information on economic benefits of green buildings (MIS=3.61). Availability of empirically proven cost data for green buildings was ranked second (MIS=3.59). Funding for construction was ranked third (MIS=3.47). Availability of green material suppliers was ranked fourth (MIS=3.43). The availability of locally sourced green building material was ranked fifth (MIS=2.93), and the least ranked was financial risks and uncertainties of rate of return of green investment and payback period (MIS=2.60).

Table 4. 9: Economic and financial-related factors influencing the sustainable development, performance, and delivery process of green construction projects

Economic and financial-related factors	1= V	2= L	3= M	4= H	5= VH	No.	MIS	Std. deviation	Ranking
Information on economic benefits of green buildings	0	1	15	10	5	31	3.61	0.803	1
Availability of empirically proven cost data for green buildings.	0	3	10	12	4	29	3.59	0.867	2
Funding for construction.	1	5	9	9	6	30	3.47	1.106	3
Availability of green material suppliers	0	10	12	6	1	30	3.43	0.742	4
Availability of locally sourced green building material.	0	10	12	6	1	29	2.93	0.842	5
Financial risks and uncertainties of rate of return of green investment and payback period.	4	8	14	4	0	30	2.60	0.894	6

Where: VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

4.2.8.4 Technical-related factors

Question 20.4 focused on the rating of the respondents' perception of the technical-related factors influencing sustainable development, performance, and delivery processes of construction projects in South Africa. Table 4.10 shows that the use of green buildings techniques was ranked first (MIS=3.94). Early identification and involvement of key project stakeholders was ranked second (MIS=3.87). Effective planning was ranked third (MIS=3.76). Use of conventional methods was ranked fourth (MIS=3.50). Design flexibility against changes during the construction phase was ranked fifth (MIS=3.35). Incremental time required in green building design was ranked sixth (MIS=3.16). Lengthy approval process of design drawings was ranked seventh (MIS=3.10). Inclusion of the contractor in the design development phase was ranked eighth (MIS=3.06). Scarcity of contractors with green building experience was ranked ninth (MIS=2.90). Lengthy green material specifications were ranked tenth (MIS=2.75). Lack of knowledge of the appropriate procurement delivery method for

green construction projects was ranked eleventh (MIS=2.41). Lastly, the least ranked factor is the slow tendering process (MIS=2.39).

Table 4. 10: Technical-related factors influencing the sustainable development, performance, and delivery process of green construction projects

Technical-related factors	1= VL	2= L	3= M	4= H	5= VH	No.	MIS	Std. deviation	Ranking
Use of green buildings techniques.	0	1	8	16	8	33	3.94	0.788	1
Early identification and involvement of key project stakeholders.	1	2	6	13	9	31	3.87	1.024	2
Effective planning.	1	2	7	17	6	33	3.76	0.936	3
Use of conventional methods.	0	1	16	13	2	32	3.50	0.672	4
Design flexibility against changes during the construction phase.	1	2	16	9	3	31	3.35	0.877	5
Incremental time required in green building design.	0	7	14	8	2	32	3.16	0.860	6
Lengthy approval process of design drawings.	3	5	8	12	1	29	3.10	1.081	7
Inclusion of the contractor in the design development phase.	5	6	8	6	6	31	3.06	1.365	8
Scarcity of contractors with green building experience.	4	6	12	7	2	31	2.90	1.106	9
Lengthy green material specifications.	5	6	13	8	0	32	2.75	1.016	10
Lack of knowledge of the appropriate procurement delivery method for green construction projects.	6	13	7	6	0	32	2.41	1.012	11
Slow tendering and procurement processes.	5	14	8	3	1	31	2.39	0.989	12

Where: VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

4.2.8.5 Social-related factors

Question 20.5 focused on the rating of the respondents' perception of the economic and financial-related factors influencing sustainable development, performance, and delivery processes of construction projects in South Africa. Table 4.11 shows that the Implementation of health and safety management systems on site (MIS=4.32). Effective communication among project stakeholders (i.e., owner, designer, contactors, and end-users) was ranked second (MIS=3.97) and the least ranked was community input for natural resources protection during site selection (MIS=2.32).

Table 4. 11: Economic and financial-related factors influencing the sustainable development, performance, and delivery process of green construction projects

Social-related factors	1= Very Low	2= Low	3= Moderate	4= High	5= Very High	Total	MIS	Std. deviation	Ranking
Health and safety at workplace	1	0	1	15	14	31	4.32	0.832	1
Effective communication and engagement among project stakeholders	1	2	5	14	11	33	3.97	1.015	2
Community input during site selection process	8	11	6	6	0	31	2.32	1.077	3

Where: VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

4.2.8.6 Environmental-related factors

Question 20.6 focused on the rating of the respondents' perception of the environmental-related factors influencing sustainable development, performance, and delivery processes of construction projects in South Africa. Table 4.12 shows that the utilization of energy-saving techniques was ranked first (MIS=4.48). Inclusion of water-saving initiatives was ranked second (MIS=4.36). Effective stormwater management was ranked third (MIS=4.00). Implementation of a waste management plan was ranked fourth (MIS=3.97). Location-efficient site for a green building was ranked fifth

(MIS=3.78). Use of land with low ecological value (MIS=3.59) was ranked sixth. Lastly, the least ranked was reuse and recycling of construction materials (MIS=3.38).

Table 4. 12: Environmental-related factors influencing the sustainable development, performance, and delivery process of green construction projects

Environmental-related factors	1= Very Low	2= Low	3= Moderate	4= High	5= Very High	Total	MIS	Std. deviation	Ranking
Utilization of energy-saving techniques.	0	0	2	13	18	33	4.48	0.619	1
Inclusion of water-saving initiatives on-site.	0	0	1	19	13	33	4.36	0.549	2
Implementation of effective stormwater management.	0	5	3	11	13	32	4.00	1.078	3
Implementation of a management plan for waste diverted to landfills.	0	4	4	14	11	33	3.97	0.984	4
Finding a location-efficient site for a green building.	1	3	7	12	9	32	3.78	3.78	5
Land use with low ecological value.	3	1	9	12	7	32	3.59	1.160	6
Reuse and recycling of construction materials.	3	4	9	10	6	32	3.37	1.212	7

Where: VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

4.2.9 Perception of respondents on factors influencing the development of green construction projects

Question 21 was related to further comments mentioned by a few respondents in addition to the factors influencing sustainable development, performance, and delivery process of green construction projects identified in literature as presented in Table 4.13.

Table 4. 13: Respondent's further comments regarding the factors influencing sustainable development, performance, and delivery processes of green construction projects

No.	Further comments	Gender	Age	Profession	Organization/ Sector	Years of experience in green construction	Education	Location
4	The earlier you start integrating Green Star standards into a project and the more this is done in an integrated manner, the lower the "green premium" will be, and the more the successful the greening of the building will be.	Male	46 to 50	Engineer & Sustainability Consultant	Private	22	Honours	Cape Town
18	For developments and developers to further adopt the green building initiative, there needs to be a way to show investors the benefits from a 'money' point of view - specifically if the developer is not intent on keeping the building (as is the case with residential). Once that is achieved, I believe we would see a much wider adoption and implementation. A big barrier to entry is also the cost of certification. You would mostly see that only rather big developers with the cash flow to make it possible are those implementing certification. For the average Joe it is not all that feasible.	Female	< 25	Construction Project Manager	Private	1	Honours	Cape Town
23	Decision related to the environmental performance of the project must be made upfront and the design and construction processes must be fully aligned with these decisions. All parties involved in the design, construction and operation of the project must commit to the sustainability requirements in order to realize the expected benefits.	Female	> 50	Sustainability Consultant	Private	11	Masters	Johannesburg

No.	Further comments	Gender	Age	Profession	Organization/ Sector	Years of experience in green construction	Education	Location
32	Passive low energy design is another way to design green/efficient projects which we are exploring (designing for comfort mainly and not a certification). As well as other GBCSA rating tools like NET Zero etc.	Female	31 to 35	Sustainability Consultant	Private	2	Bachelors	Cape Town
38	Stick to first principles of design & avoid "green" systems with a high maintenance requirement.	Male	41 to 45	Architect	Public	7	Masters	Cape Town
39	The private sector, especially in Hospitality (wedding venues, private lodges, etc.) and Education Services (private schools) seem to have a full grasp of the need to develop green and sustainable. Hence, the projects developed by these sectors encounter very few challenges as the owners are fully aware of the green projects' needs. On the other hand, some public departments seem to be dragging on the implementation of full green or sustainable projects due to various reasons (mainly being project capital, competency, corruption, etc.).	Male	26 to 30	Mechanical Engineer	Private	8	Masters	Cape Town
48	Awareness and education around the topic of Sustainable development feels like the biggest delay. Sustainable design and development is not only PV or water savings it has alot to do with the occupants and the way they understand their building and the interventions in place in order for them to utilize it appropriately therefore giving a value add to the savings of the building.	Female	31 to 35	Sustainability Consultant	Private	8	Bachelors	Cape Town

4.3 Data Analysis

Spearman's rho correlation was used to ascertain the correlation between the factors existing in a green construction project environment and sustainable development. Spearman Rho tests requires a null hypothesis (H_0) and alternative hypothesis (H_1). In this case, the null hypothesis is stated as follows: H_0 = There is no relationship between sustainable development and the factors existing in a green construction project environment. H_1 = There is a relationship between sustainable development and the factors existing in a green construction project environment. The results of the Spearman Correlation analysis presented in Table 4.14 shows that there is a positive relationship between sustainable development and the factors existing in a green construction project environment ($r_s = .557$, $n=33$, and $p < 0.001$). This implies that the level of contribution of green buildings to sustainable development is determined by the response to factors existing in a green construction project environment. This means that the higher the knowledge and awareness of these factors, there more the level of contribution of green buildings to sustainable development.

Furthermore, the hypothesis testing system for the sustainability performance of green construction projects is stated as follows: H_0 = There is no relationship between sustainability performance and the factors existing in a green construction project environment. H_1 = There is a relationship between sustainability performance and the factors existing in a green construction project environment. The results of the Spearman Correlation analysis presented in Table 4.14 shows that there is a positive relationship between sustainability performance (environmental and socio-economic) and the factors existing in a green construction project environment (environmental sustainability performance: $r_s = .666$, $n=33$, $p < 0.001$ and for the socio-economic impact category: $r_s = 0.491$, $n=32$, $p = 0.04$). This implies that the level of performance of green buildings is determined by the factors influencing the development of green construction projects. This means that knowledge and awareness of these factors will increase the level of sustainability performance of green buildings .

The significance testing (p-value) of the Spearman's Rho coefficients is below the 0.05 threshold (refer to Table 4. 14) signifies that the established coefficient is statistically significant. Thus, there is a 95% probability that the null hypothesis is incorrect and can be rejected.

Table 4. 14: Correlation between the green construction project environment between sustainable development and sustainability performance (environmental and socio-economic)

Items	N	Correlation coefficient (r_s)	Sig. (2-tailed)
Factors existing in a green construction project environment			
Sustainable development	33	.557**	<.001
Environmental sustainability performance	33	.666**	<.001
Socio-economic impact	32	.491**	.004

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

4.4 Discussion of findings

This section provides a discussion of the findings of the study which sets out to measure the level of the factors influencing sustainable development, performance, and delivery processes of green construction projects in the context of the South African construction industry. The findings will be presented in relation to the research objectives to determine whether the objectives of the study have been satisfied. The findings will also be aligned to the reviewed literature covered in Chapter 2.

4.4.1 Level of contribution of green construction projects to sustainable development

The contribution of green construction projects to sustainable development, rated from very low to high significance was calculated using the MIS in accordance with the environmental, economic, and social aspects. The survey outcome shows that the implementation of green construction projects contributes to environmental protection, economic growth, and social equity in order of importance.

4.4.1.1 Environmental protection

The importance of environmental protection is consistent with several authors such as Darko and Chan (2016), Goubran (2019), and Florez (2020), who suggested that the implementation of green buildings can contribute to the achievement of sustainable development as they reduce the environmental impact of buildings on climate change

and greenhouse gas emissions. The positive response regarding inclusion of environmental protection in projects further supports that buildings impact the environment throughout the project's life cycle, starting from design, construction, operation, and demolition (Ametepey et al., 2015). Respondent 23 stated that *'Decision related to the environmental performance of the project must be made upfront and the design and construction processes must be fully aligned with these decisions. All parties involved in the design, construction and operation of the project must commit to the sustainability requirements to realize the expected benefits.'* (refer to Table 4. 13: Respondent's further comments regarding the factors influencing sustainable development, performance, and delivery processes of green construction projects). It is important to note that green construction does not only contribute to the environmental protection; additionally, it provides social and economic benefits. Therefore, green construction integrates the three fundamental aspects of sustainable development such as environmental protection, economic growth, and social equity (Brundtland, 1987).

4.4.1.2 Economic growth

The findings show that economic growth is ranked after environmental protection. The consideration of environmental protection in green construction results in economic growth which can be translated to green economy. An example of a green economy is mentioned in literature where the environmental aspects of green buildings help to maximise economic benefits through job opportunities, increased employee productivity, improved health and safety benefits, savings from energy and water savings, and maintenance and operational costs which can lead to high property value of a building (Lavrinenko et al., 2019).

4.4.1.3 Social equity

The number of respondents who consider social equity to be of high to very high importance in the projects is small when compared to those that consider social equity to be of moderate importance. This relates to the literature signifying that even though the social aspect of green construction has been marginalized for an extended period. It is slowly gaining traction in the construction industry (Karji et al., 2021). As time

progresses and more professionals incorporate the social aspect in green construction projects, the holistic view of the contribution of green buildings to sustainable development will be fulfilled.

4.4.2 Level of performance of green construction projects in terms of sustainability

In this study, the results reveal the following from the level of performance of green construction projects in terms of sustainability. Sustainability in the study incorporates environmental sustainability performance and socio-economic impact indicators as outlined by the GBCSA.

4.4.2.1 Environmental sustainability performance

The study made a comparison between the Green Star certification tool and the two most globally recognised green building certification tools. The study deduced that; sustainability performance is assessed similarly throughout the various global green building councils. Environmental sustainability performance is assessed in accordance with the nine categories stipulated by the GBCSA. The categories that are assessed include management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, and innovation.

In the literature, indoor environment quality, energy efficiency, and water conservation have become an emphasis as the drivers of green building adoption (Hurlimann, 2008; Cheng et al., 2016; Patnaik et al., 2018; Oguntona et al., 2019; Licina et al., 2021; Amoah and Smith, 2022; Liu, 2022). The findings of the study reveal that indoor environment quality (IEQ) is the first ranked with a MIS of 4.27. 94% of the respondents indicated the extent to which IEQ was present in their projects is high to very high. Improved IEQ in buildings in terms of increased ventilation, controlled temperature and lighting, and maximum use of natural light has provided building owners motivation to go green. Research shows that improved IEQ incorporated in green buildings contributes to a greater occupant's satisfaction, improved health and productivity, and well-being (Simpeh and Smallwood, 2018; Bungau, 2022).

Given the energy and water crisis globally and in South Africa, building owners have benefited from the use of green buildings through the reduction of building utility costs. The majority of respondents pay much attention to energy efficiency and water conservation as these were ranked second and third position, respectively. Energy efficiency is one of the most common traits of green construction. This is made possible through the implementation of renewable sources such as solar and wind energy (Nilashi et al., 2015). Studies show that Green Star certified buildings save between 25% and 50% on energy costs when compared to conventional buildings (GBCSA, 2020). The water saving initiatives used in green buildings promote water efficiency (Polat et al., 2017).

The GBCSA aims to encourage the implementation of policies, procedures, targets, and strategies that promote best practice sustainability outcomes throughout the operation of a building (GBCSA, 2020). The building and construction sector is a key contributor to greenhouse gas emissions. Carbon is a key greenhouse gas and contributes to climate change and environmental degradation. The building and construction sector is one of the major sectors that consume energy and indirectly produce energy-related CO₂ emissions which are detrimental to the environment (Ahmed Ali et al., 2020). Since energy consumption indirectly produces carbon emissions by using fossil fuels to produce energy, minimizing energy consumption of a building mitigates carbon emissions (Bungau et al., 2022).

The respondents indicated that a building location near public mass transport network is significant. This category in the GBCSA rating tool rewards alternative use of transport and the reduction of automotive commuting within the building. Research conducted by CSIR on sustainable building assessment tool reveals that a site location far from public mass transport network is an inconvenience and results in increased environmental footprint. Hence a building location near public mass transport network should be a key factor in the site selection process (Gibberd, 2008). To satisfy the sustainable transport requirements, Mathetha and Muzi (2017) suggest that there should be an effective collaboration between project stakeholders and transport authority professionals.

The GBCSA has incorporated the innovation category in the rating system to encourage the incorporation of innovative practices, technologies, designs, and processes that can influence environmental performance of a building (GBCSA, 2014). The least ranked environmental performance indicator is reuse and recycling of construction materials. The use of green construction materials does not only reduce the damage to the environment, but also improves the environmental ecological benefits (Zenios and Allen, 2016). Sustainable land use is one of the concepts used in green buildings that can contribute to the improvement of biodiversity and ecosystem enhancement by minimizing the impact of buildings on ecological systems, and reducing natural resource consumption and waste generated from construction activities (Lin et al., 2016). More than 50% of the respondents ranked each of the environmental sustainability performance category as significant in green construction projects. The results of the findings agree and are consistent with the literature.

4.4.2.1 Socio-Economic Impact Category

The ranking of the socio-economic impact of green construction projects was calculated using the MIS in accordance with the seven categories that the Green Star rating tool considers. This is an optional category that buildings who qualify for Green Star certification can apply for. The optional socio-economic impact category consists of seven factors which include health and safety, skills development and training, implementation of BBEE, employment creation, economic opportunity, community benefit, and creation of mixed income housing options – multi-unit residential.

All the socio-economic impact indicators were ranked moderately significant except for the creation of mixed income housing options. The first ranked socio-economic category is improved health and safety in the workplace. This rating further proves that socio-economic impact of green construction is not fully viewed as a significant aspect influencing green building projects (Robinson, 2004).

4.4.3 Ascertain the phases in the delivery process of green building projects with the highest environmental impact.

The phases of the delivery processes that are relevant to this study include procurement, design, and construction. This study sought to establish the phases in the green building delivery process with the highest environmental impact. The delivery processes that were included in the questionnaire are construction and procurement delivery phases.

4.4.3.1 Construction delivery phases

The findings reveal that the mostly used construction delivery method by the respondents was the in-situ on-site construction method. However, the in-situ on-site method is reported to have a high environmental impact and has been long associated with unsustainable construction due to higher greenhouse gas emissions (Shen et al., 2009). The literature reveals that the cast in-situ method has a high environmental impact and violates the environmental sustainability indicators (increased energy consumption, increased construction waste, increased greenhouse gas emissions) when compared to precast off-site and prefabricated materials (Wong and Loo, 2022). Wong and Loo state that the adoption of cast in-situ on-site construction methods requires increased energy consumption, increased construction waste and increased operational costs. The use of precast method provides a safer working environment for construction workers and reduces accidents associated with the cast in-situ method.

4.4.3.2 Procurement delivery phase

One of the initial steps in a construction project is selecting an appropriate project delivery method. However, research shows that there is no definite procurement delivery method for green building projects (Korkmaz et al., 2011). Different project teams have their own preference as some state that the most appropriate delivery method to use is Design-Build (Ramkrishnan et al., 2007). In the literature Opoku and Ahmed (2014) proves that project stakeholders are more likely to adopt Design-bid-Build (traditional method) to avoid additional responsibilities required in green

construction. This was the case with the respondents of this study as they selected the Design-bid-Build as the most utilized procurement delivery method.

The procurement delivery method that was implemented in the green construction project was not modified to suit the requirements of a sustainable building project. Although the selection of an appropriate procurement delivery method is important as it determines the structure of the project from start to finish. Chan et al. (2017) state that the environmental impact of the procurement method is not quantifiable, however; the aspects that minimize the environmental impact of buildings in addition to the appropriate procurement phase include the early involvement of key project stakeholders, effective team collaboration, and use of green technology. Some of the factors impacting on the project delivery processes of green buildings are discussed in section 4.4.4 Establish the factors influencing sustainable development, performance, and delivery processes in green building projects.

4.4.4 Establish the factors influencing sustainable development, performance, and delivery processes in green building projects

The extent to which the factors were present in green construction projects of the respondents were rated from very low to very high, using the MIS and SD.

4.4.4.1 Knowledge and awareness-related factors

Expressed interest and demand of green buildings was ranked as the highest knowledge and awareness related factor. A green construction project involves different stakeholders (e.g., owner/client, designer, contractor, and end-user). However, the client and end-user are key stakeholders. The client is a key decision maker and determines if a green construction project will be executed. Conversely, an end-user decides whether they want to use the building. Hence, it is difficult or impossible for a project team to execute a green construction project if the client and/or end-user are not interested (Korkmaz et al., 2010; Darko and Chan, 2017).

Interest and demand of green construction can be cultivated if client/end-user awareness of green construction is developed. The respondents indicated that professional knowledge of green buildings is significant. A lack of professional

knowledge and awareness of green construction can be a hindrance to the growth of sustainable buildings (Hwang and Tan, 2012). The respondents indicated an importance of knowledge of software used to improve green building designs such as Life-Cycle Analysis tools, Building Information Modelling (BIM), and so on. The use of software such as BIM in green construction projects is an emerging concept and the built environment professionals confirm that the implementation of such software tools enhances the delivery of green construction projects (Zhang et al., 2019).

Inadequate research and information on benefits and methods of green technologies because of insufficient education and training contributes to a lack of awareness of benefits of green construction. Respondent 48 (refer to Table 4. 13: Respondent's further comments regarding the factors influencing sustainable development, performance, and delivery processes of green construction projects) mentioned that *'Awareness and education around the topic of Sustainable development feels like the biggest delay. Sustainable design and development are not only PV or water savings it has a lot to do with the occupants and the way they understand their building and the interventions in place for them to utilize it appropriately therefore giving a value add to the savings of the building.'* Public awareness of green construction is essential because it leads to the high demand, and consequently, the improved delivery of green construction.

4.4.4.2 Governmental-related factors

Respondents ranked the enforcement of green building codes the highest governmental-related factor. Enforcement of green building codes affects the project delivery – hence building codes and regulations that incorporate all green building aspects and sustainable objectives are necessary to ensure effective project delivery (Darko and Chan, 2017; Zhang et al., 2019). The implementation of green construction requires appropriate government policies, procurement standards and regulations which include: promotion of the utilization of energy-saving techniques; waste management; commendation of low taxes and tariffs on green construction products; governmental support and incentives; and training programs offered by the government (Owusu-Manu et al., 2022).

The least ranked factor is governmental support or incentives for promoting green buildings; respondents indicated that the presence of governmental support/incentives was very low to low. A lack of governmental incentive to promote green construction is consistent with the previous studies (Simpeh et al., 2020). In addition to a lack of governmental incentives, respondents indicated very low to low funding for research and the implementation of green buildings. Simpeh et al. (2020) note that there is inadequate research funding for green building research. Darko et al. (2017) urge the government to provide subsidies for the research and development of green buildings as poor market demand for green buildings is due to the lack of credible research.

The findings reveals that the government legislative procedures and documents required are complex (Zhang et al., 2019). Darko et al. (2017) indicated that the submission documents required for legislative procedures of green buildings is becoming more complex, preventing developers from seeing the benefits of green construction. Research reveals that there are delays in obtaining authority approvals and permits to execute green construction projects (Simpeh et al., 2020). However, in this study respondents indicated that the delay of green building projects by local authorities was minimal. Some experts in the industry have indicated that collaboration between developers and transport planning authorities is required as the submission documents for this category is cumbersome (Mathetha and Muzi, 2017). Respondents indicated very low collaboration between developers and transport planning authorities.

4.4.4.3 Economic and financial-related factors

Simpeh et al. (2020) note that inadequate information on green building opportunities and benefits is caused by a lack of quantitative documentation of benefits and uncertainties associated with green construction. Information on economic benefits of green buildings was the first ranked under the economic and financial related factors. 50% of respondents indicated that the availability of such information was moderate while the other indicated high to very high availability. This indicates that professionals must ensure that information on economic benefits of green buildings is explicitly available as respondent 18 (refer to Table 4.13) has indicated that *‘for developments and developers to further adopt the green building initiative, there needs to be a way*

to show investors the benefits from a 'money' point of view - specifically if the developer is not intent on keeping the building (as is the case with residential). Once that is achieved, I believe we would see a much wider adoption and implementation. A big barrier to entry is also the cost of certification. You would mostly see that only rather big developers with the cash flow to make it possible are those implementing certification. For the average Joe it is not all that feasible'. Respondents indicated high availability of empirically proven cost data for green buildings. There is no definite answer as to the cost data of green construction. However, Kats (2013) in his book *Greening our built world: costs, benefits, and strategies* conducted a study and deduced that green buildings do not incur an additional 17% capital cost as perceived by the public as the average capital premium for green buildings is 1.5% more than their counterpart. Respondents indicated moderate financial risks and uncertainties of rate of return of green investment and payback period. Chițimiea et al. (2021) argue that the payback period of green construction is much longer. However, Simpeh and Smallwood (2015) argue that green buildings offer a better payback period because of energy and water efficiency.

Availability of more financing options for green construction is one of the top drivers of green construction projects for the respondents. The South African government has introduced the Green Fund which is a national fund offering catalytic finance for green initiatives investment while providing support to the transition towards a green economy (Mohamed et al., 2014). Despite the green fund that has been provided by the South African government, respondents have indicated that availability of green suppliers and locally sourced green materials is still limited and this is consistent with the findings of Shi et al. (2013).

4.4.4.4 Technical-related factors

It is important to note that green buildings do not only minimize carbon emissions, rather they also include improved indoor air quality, energy-saving, water efficiency, improved occupants' health, and wellbeing (Zenios and Allen, 2016). The preferred use of green building techniques by respondents is growing and in support of that, Respondent 39 (refer to Table 4:13) has indicated that, *'The private sector, especially in Hospitality (wedding venues, private lodges, etc.) and Education Services (private*

schools) have a full grasp of the need to develop green and sustainable. Hence, the projects developed by these sectors encounter very few challenges as the owners are fully aware of the green projects' needs. On the other hand, some public departments are dragging on the implementation of fully green or sustainable projects due to several reasons (project capital, competency, corruption, etc)'. One of the ways to ensure successful implementation of green construction projects is effective planning (Korkmaz et al., 2011) and the early identification and involvement of key project stakeholders. Respondent indicated high importance of early identification and involvement of key project stakeholders. Korkmaz et al. (2010), Zhang et al. (2019), and Wu et al. (2021) state that early identification and integration of project participants ensures that stakeholders have a clear understanding of the project requirements, especially in the early stage in the delivery of the project. Early identification and integration of projection participants requires the identification of a contractor. However, respondents indicated high scarcity of contractors with green building experience. Gultekin et al. (2013) inferred that there is usually a small selection pool of contractors and subcontractors with knowledge and experience in green construction projects.

Korkmaz et al. (2011) and Gultekin et al. (2013) noted that the early involvement of a contractor in the delivery processes is essential for the achievement of sustainable buildings especially in the design and development phase. The designer and contractor are selected through a procurement method. Respondents indicated that there was knowledge of the appropriate procurement delivery method for green construction projects. There is no definite procurement method to be used for green buildings. Several researchers have different opinions. Some state that the most appropriate delivery method to use is Design-Build (Korkmaz et al., 2011). Opoku and Ahmed (2014) argue that stakeholders are more likely to implement Design-Bid-Build (traditional method) to avoid additional responsibilities required in green construction. Ayarkwa et al. (2022) indicate that there is slow tendering and procurement processes involved in green construction. The findings of this study indicated this factor as having a low significance. Respondents indicated that the lengthy approval process for green projects was significant Darko et al. (2017) state that the lengthy approval process for green construction could affect the management of the project such as increased time of completion. Shi et al. (2013) argues that incremental time caused by green

construction is one of the factors limiting the growth of green buildings. Additionally, respondents indicated that green material specification are moderately long. This is an improvement from what was deduced by Darko et al. (2017) who indicated that there are lengthy green material specifications in designs.

4.4.4.5 Social-related factors

Respondents ranked the implementation of health and safety management in the workplace as the highest social-related factor. Simpeh and Smallwood (2018) notes that comfort, occupants' health, and safety are some of the important social benefits of green buildings. To obtain a successful green construction project, respondents agree that effective communication and engagement among project stakeholders (owner, designer, contractors, and end-users) is required. Hwang and Tan (2012) view communication among project participants as crucial since every member requires an in-depth understanding of green buildings before and during the building's life cycle. Lastly, the least ranked social-related factor was engagement of community for natural resources protection during site selection. Attaran and Celik (2013) view the community as the significant stakeholders who should be included in the site selection process as the public or end-user have a role to play in sustainability outcome of the building.

4.4.4.6 Environmental-related factors

Respondents indicated that the most significant environmental factors in green construction are utilization of energy-saving techniques, inclusion of water-saving initiatives on-site. Literature demonstrates that designers who incorporate energy and water saving techniques have managed to reduced energy and water consumption (Zhang et al., 2019). In addition, respondents regarded sustainable stormwater management, location of site, land use and ecology, the use of green construction materials, and an effective waste management plan as crucial in green construction projects.

It is important to note green construction practices are interlinked. For instance, the water-saving techniques used in green construction improves the quality of water

through the implementation of effective stormwater management in projects. Green construction includes sustainable stormwater management which reduces runoffs and contaminants from the water that reaches waterways. An efficient site location for a green building is essential as it can reduce environmental impact on land and ecology and contribute to energy and water efficiency. Environmental ecological benefits are also improved using green construction materials (Zenios and Allen, 2016). Waste generated through the construction processes requires an efficient waste management plan for storage, collection of waste diverted to landfills, and a re-use of recyclable construction materials (Shabrin and Kashem, 2017).

4.4.5 Relationship between sustainable development, sustainability performance and the factors existing in a green construction project environment

Spearman's Rho correlation was used to test the hypothesis established in Chapter 1 (section 1.5) . A correlation between the factors influencing the development of green construction projects and independent variables (sustainable development and sustainability performance) was determined. The study found a positive relationship between sustainable development, sustainability performance, and the factors influencing the development of green construction projects. The factors affecting sustainable development, performance, and delivery processes were found to be similar which means that when a specific factor exists in a green construction project, it can impact any if not all the three parameters discussed in this study. This finding validates the hypothesis; therefore, the hypothesis was accepted.

4.5 Chapter Summary

The finding of the research reveals that the objectives of the study were satisfied and are aligned to the existing literature. Collected data were analysed using SPSS version 28. Data were presented in a form of descriptive statics, a test of hypothesis, and inferential statistics. The summary of the findings and concluding remarks will be discussed in the succeeding chapter.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section is the concluding chapter of the research study. This chapter provides a summary of research findings, concluding remarks, and recommendations. Further areas of study that will be beneficial to the built environment professionals involved in green construction projects in South Africa were outlined. The principal aim of the study was to investigate the factors influencing sustainable development, performance, and delivery processes of green building projects. To achieve this aim, the research objectives that guided the study are re-stated as follows:

1. Find out the level of the contribution of green construction projects to sustainable development.
2. Determine the level of performance of green construction projects in terms of sustainability.
3. Ascertain the phases in the delivery process of green building projects with the highest environmental impact.
4. Establish the factors influencing sustainable development, performance, and delivery processes in green building projects.

Additionally, the following hypothesis was used to guide the information that will be included in the questionnaire survey of the study:

There is a relationship between sustainable development, sustainability performance, and the factors influencing the development of green construction projects.

5.2 Summary of Findings

The study successfully satisfied all the proposed research objectives. The summary of the findings distributed according the objectives are stated below.

5.2.1 Level of contribution of green construction projects to sustainable development

Sustainability is a holistic concept that integrates environmental, social, and economic aspects. The study established that green construction contributes to sustainable development. However, in the implementation of buildings much focus is placed on environmental protection. This is important as the reduction in greenhouse gas emissions can ensure the achievement of Sustainable Development Goal 13 which aims to combat climate change with immediate action. The findings show that economic growth is ranked after environmental protection. The green practices that contribute to environmental protection result in economic growth. Following economic growth is social equity. The study established that social equity is not usually one of the major aspects influencing green building projects. Even though the social aspect of green buildings has been marginalized for a long period it is starting to gain attention, as indicated by the findings. This is expected to improve as more professionals become aware of the benefits of green construction.

5.2.2 Level of performance of green construction projects in terms of sustainability

A sustainable building extends beyond reuse and recycle of building material, energy, and water efficiency. It emerged that human sustainability is of paramount importance as the indoor environment quality was the most importantly ranked environmental performance indicator for green construction projects. The incorporation of energy and water efficiency in buildings is beneficial to the developing countries like South Africa where there is a constant shortage of water and electricity supply.

The respondents ranked the socio-economic impact indicators as moderately significant in their projects with the creation of mixed income housing options – multi-unit residential – ranked as very low significance. This may signify that at this point most professionals are not yet involved in the green construction of multi-residential units. The fact that all the socio-economic impact indicators were ranked moderately significant in green construction projects suggests that the socio-economic impact

category requires more attention in order to ensure that a holistic view of sustainability is achieved.

5.2.3 Ascertain the phases in the delivery process of green building projects with the highest environmental impact

Procurement and construction delivery methods were evaluated in this study. The findings reveal that the environmental sustainability in procurement systems is achieved when incorporated with factors such as early involvement of key project stakeholders. Based on the findings, the phase in the delivery process of green buildings with the highest environmental impacts is the construction phase.

5.2.4 Establish the factors influencing sustainable development, performance, and delivery processes in green building projects.

The factors influencing sustainable development, performance, and delivery processes of green construction projects are classified in terms of knowledge and awareness, governmental, economic, as well as financial, technical, social, and environment related factors in the literature. The research findings reveal that the factors influencing sustainable development, performance, and delivery processes of green construction projects in South Africa as identified from reviewed literature were all significant. The top ten highest ranked variables are: the utilization of energy-saving techniques; inclusion of water-saving initiatives on-site; health and safety management systems in the workplace; enforcement of green building codes/regulations; expressed interest; and demand from clients; implementation of effective stormwater management; implementation of a management plan for waste diverted to landfills; effective communication and engagement among project stakeholders; professional knowledge and experience/skills in green buildings; and the use of green buildings techniques.

Notwithstanding the fact that all the reviewed factors are significant, however, the findings reveal that the least ranked factors are all governmental-related. The respondents ranked governmental support or incentives as having a very low significance in their green construction projects.

5.2.5 Revisiting the Research Question

What factors influence sustainable development, performance, and delivery processes of green building projects in the South African construction industry?

In this study, the factors that influence the development of green construction projects in South Africa contribute significantly to the sustainable development and sustainability performance of buildings. Knowledge of these factors will improve the development of green construction in the South African construction industry throughout the building's delivery processes, thus reducing difficulties in achieving sustainable buildings. A lack of understanding of these factors may result in defective delivery processes of green buildings.

5.3 Conclusion

Based on the evaluation of findings, the following conclusions are made:

- Green construction contributes to sustainable development. However, project stakeholders give more emphasis to environmental protection and economic growth, and less emphasis is directed to social development.
- Green professionals view building sustainability performance as significant in the following order of importance: indoor environment quality, energy efficiency, water conservation, management and maintenance of building systems, emissions reduction, building location near public mass transport networks, innovation, land use and ecology, and the reuse and recycling of material. Human sustainability is of paramount importance in green construction since the study established that indoor environment quality was the highest ranked environmental sustainability performance indicator.
- Currently, the in-situ on-site construction method is mostly used in green construction projects and this construction delivery method has the highest environmental impact.

- The findings revealed that of the factors influencing the development of green construction projects most are environmental-related. However, Knowledge of factors involved in the development of green construction projects can be used by built environment professionals to provide insights into how to manage green construction projects and make better-informed decisions.
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5.4 Recommendations

The following recommendations are made according to who is in the best position to address the problems identified by the study.

5.4.1 Built environment professionals

- Sustainable development in green buildings is achieved when the buildings perform sustainably. However, in order for buildings to perform sustainability, project stakeholders must decide during the initiation phase of the project whether they are targeting green certification. Knowledge of this will ensure that projects are managed sustainability from initiation to closeout phase, including the operation, maintenance, and demolition stages.
- To ensure that buildings are delivered sustainably organizations should include a requirement that professionals who work in building projects must have a valid green certification so that the accredited professionals can provide insights into managing green construction project delivery and incorporate sustainability in buildings.

5.4.2 Clients/Owners

- The study revealed that the factors which influence the development of green construction projects, most are environmental related. Therefore, clients/owners must ensure that they appoint stakeholders (i.e., designer and contractor) with adequate green building knowledge to promote environmental and socio-economic sustainability in projects.

5.5 Areas for Further Research

Further research can be undertaken in the following areas:

- The factors discussed in this study were based on the perceptions of the respondents, which is the most important step to solicit information in terms of exploring the factors existing in the green project environment. However, to obtain better improved results, further research is required to measure real data from the existing Green Star certified buildings. This can be used to compare whether the factors perceived by the respondents to exist in green building projects match the real data measured from existing, green-certified buildings.
- The four least important ranked factors are all governmental-related. Further research on solutions to improve the governmental-related factors associated with green construction projects is required as the government has a significant role to play in the sustainable development of buildings. Furthermore, insights into the role that the government plays in the implementation of green buildings or green construction projects would be useful to determine solutions that can improve the contribution of governmental-related factors in the successful implementation of green buildings.
- The GBCSA certifies green buildings in South Africa and in Africa. Future studies can investigate the factors affecting environmental sustainability performance and socio-economic impact of green construction projects in other African countries to confirm the findings of this study.
- Green rating tools focus on different phases of the building's life cycle. Further research to establish an association between socio-economic impact indicators and the project delivery phases to ensure a successful delivery of green construction projects.
- Cast in-situ on-site construction method have high impact on the environment; however, it is still used in green construction. Further research can be done to

investigate ways in which the environmental impact of cast in-situ construction methods can be decreased to promote sustainability in projects.

- This study employed a quantitative approach and a questionnaire was prepared based on available literature that also followed a quantitative approach. Future studies can explore the factors influencing sustainable development, sustainability performance, and delivery processes of green construction projects using a qualitative approach to gain insights into the actual factors that exist in green construction projects. Research findings from a qualitative study can be used to validate the findings of this research.

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APPENDICES

Appendix A: REC Approval



2022/11/08

EBE/02033/2022

RE: Research Ethics Committee Project Approval Letter

Dear Palesa Singata,

Your application for ethics review of your project titled

INVESTIGATING FACTORS INFLUENCING SUSTAINABLE DEVELOPMENT, PERFORMANCE, AND DELIVERY PROCESSES OF GREEN CONSTRUCTION PROJECTS IN SOUTH AFRICA.

has been reviewed and evaluated by the

CEM:Dept. of Construction Econ&Managemnt Research Ethics Committee (REC).

Based on the information supplied your application has been successful and is approved.

You may proceed with your research project titled:

INVESTIGATING FACTORS INFLUENCING SUSTAINABLE DEVELOPMENT, PERFORMANCE, AND DELIVERY PROCESSES OF GREEN CONSTRUCTION PROJECTS IN SOUTH AFRICA.

Please note that should:

- (i) any serious or adverse effects to participants occur and/or,
- (ii) aspect(s) of your current project change and/or
- (iii) any unforeseen events that might affect continued ethical acceptability of the project occur then you should immediately report this to the approving REC. You may be required to submit an amendment to this application, in order to determine whether the changed aspects increase the ethical risks of your project.

Please note the following additional conditions associated with this approval:

- (i)

Regards,

CEM:Dept. of Construction Econ&Managemnt

Research Ethics Committee

Appendix B: Consent Form and Information Sheet

Good day, my name is Palesa Singata, and I am conducting research towards a Master of Science in Project Management degree at the University of Cape Town. I would like to invite you to participate in the questionnaire survey. I would like to solicit information from the GBCSA's Green Star accredited professionals on the factors influencing sustainable development, performance, and delivery processes of green construction projects in South Africa.

Please note that your participation is completely voluntary. There will be no negative consequence if you choose not to participate. If you choose to participate, you are free to withdraw at any time without negative consequence. However, I would greatly appreciate if you would complete the survey. The survey is confidential, and your anonymity will be preserved throughout the research. Your name will not be included, participant codes will be used on the forms to label collected data. You will not encounter any risk of harm, discomfort, emotional upset, stigmatization during the survey.

Data obtained from the survey will be used solely for the purposes of this research. There will be no direct benefits to participating. However, your response will assist with the study and contribute towards the Green Buildings research in South Africa. If you agree to participate in this study, the questionnaire survey will be made available to you and will be completed on Google Forms. It will not take more than 15 minutes of your time. The survey comprises of two sections. Section 1: Respondent's background information, and Section 2: Factors existing in a green construction project completed in the last five years.

Kindly indicate if you would like to receive a summary of the results. For further information regarding this study, do not hesitate to contact the researcher, Palesa Singata via email: MNTPAL003@myuct.ac.za or the supervisor, Professor Abimbola Windapo via email: abimbola.windapo@uct.ac.za.

Name of participant: Date:

Signature of participant:

Appendix C: Questionnaire Survey

INVESTIGATING FACTORS INFLUENCING SUSTAINABLE DEVELOPMENT, PERFORMANCE, AND DELIVERY PROCESSES OF GREEN CONSTRUCTION PROJECTS IN SOUTH AFRICA

SECTION 1: RESPONDENT'S BACKGROUND INFORMATION

PLEASE ANSWER THE FOLLOWING QUESTIONS AND MARK WITH AN X WHERE APPLICABLE.

1. Gender:

Male	
Female	

2. Age:

YEARS	
Under 25	
26-30	
31-35	
36-40	
41-45	
46-50	
Over 50	

3. Kindly indicate your level of highest educational qualification.

Higher Certificate	
Diploma	
Bachelor's degree / Advanced Diploma	
Honour's degree	
Master's degree	
Doctoral degree	
If other, please specify:	

4. Please indicate your professional background.

Architect	
Quantity Surveyor	
Town/ Regional Planner	
Construction Manager	
Construction Project Manager	
Engineer Specify:	
Property valuer	
If other, please specify:	

5. In the list given below, please identify the type of organization that you work for.

ENTITY	
Public sector	
Private sector	

6. Please indicate your number of years of experience in the construction industry.... (e.g., 5 years) and green building ... (e.g., 5 years).

7. Kindy indicate the building sector that is specific to you.

BUILDING SECTOR	
Office	
Retail	
Multi-unit residential	
Public	
Educational	
If other, please specify:	

8. Are you a Green Star accredited professional?

Yes	
No	

If yes, kindly specify the year of your Green Star accredited programme and year of registration.... (e.g., Green Star New Building- 2019)

9. Please indicate the number of green building projects implemented.(e.g.,

5) Please specify how many of those projects qualified for a Green Star SA certification?... (e.g., 5)

10. Please indicate how many of the above-mentioned green construction projects qualified for the optional socio-economic impact category. (e.g., 1, 2, ..., All, None)

11. Please indicate from the list below, the methods through which you have improved your green construction experience and knowledge over the years.

EVENT	
Continuing Professional Development /GBCSA courses	
Organizational workshops/ Conference attendance	
Online publications and articles	
Further education and training	
Involvement in green construction projects	
Other, please specify:	

SECTION 2: FACTORS INFLUENCING THE SUSTAINABLE DEVELOPMENT, PERFORMANCE, AND DELIVERY PROCESS OF GREEN CONSTRUCTION PROJECTS

Kindly identify a Green Star rated project, which you are conversant with, and which was completed in the last five years. Kindly use your knowledge of the project in answering the following questions.

12. When was the project completed? (e.g., 2020)

13. Where is the project located? (e.g., Cape Town)

14. What is the Green Star rating of the project? (e.g., 5).

15. Rate on a scale of 1 to 5, where 5 is very high and 1 is very low, the extent to which this building meets the present needs without compromising the needs of future generations in terms of the following areas:

No.	SUSTAINABLE DEVELOPMENT					
1	Environmental protection	1	2	3	4	5
2	Economic growth	1	2	3	4	5
3	Social equity	1	2	3	4	5

16. Rate on a scale of 1 to 5, where 5 is very high and 1 is very low, the extent to which the building achieves the following sustainability performance indicators?

No.	ENVIRONMENTAL SUSTAINABILITY PERFORMANCE INDICATORS					
1	Management (sustainable maintenance and operation of building systems)	1	2	3	4	5
2	Indoor environment quality	1	2	3	4	5
3	Energy Consumption/Demand	1	2	3	4	5
4	Building location near public mass transport networks	1	2	3	4	5
5	Water Consumption/Demand	1	2	3	4	5
6	Reuse and recycling of construction materials.	1	2	3	4	5
7	Land use and ecology	1	2	3	4	5
8	Reduction of greenhouse gas emissions	1	2	3	4	5
9	Implementation of innovative technologies, designs, and processes	1	2	3	4	5

17. Rate on a scale of 1 to 5, where 5 is very high and 1 is very low, the extent to which the building achieves the following sustainability performance indicators?

No.	SOCIO-ECONOMIC IMPACT CATEGORY					
1	Employment creation	1	2	3	4	5
2	Economic opportunity	1	2	3	4	5
3	Skills development and training	1	2	3	4	5
4	Community benefit	1	2	3	4	5
5	Implementation of Broad-Based Black Economic Empowerment (BBBEE) principles	1	2	3	4	5
6	Improved health and safety for construction workers	1	2	3	4	5
7	Creation of mixed income housing options (Applicable to Multi Unit Residential Projects)	1	2	3	4	5

18. Kindly indicate the delivery process used on the project.

CONSTRUCTION METHOD	
Pre-cast off site	
In-situ on-site construction	
Hybrid – involving both offsite and in-situ methods of construction	

19. Kindly indicate the procurement delivery method used on the project.

PROCUREMENT DELIVERY METHOD	
Design-Bid-Build (DBB)/ Traditional method	
Design - Build (DB)	
Construction Management at Risk (CMR)	
Other, please specify:	

20. Was the delivery method selected above modified to accommodate the green building project?

Yes	
No	

21. Please indicate on a scale of 1 to 5, where 5 is very high and 1 is very low, the extent to which the following factors were present on the project implemented.

No.	FACTORS					
Knowledge and awareness						
1	Professional knowledge and experience/skills in green buildings (including client, designer, and contractor).	1	2	3	4	5
2	Knowledge of software to prepare green building designs (e.g., Life-Cycle Analysis tools, Building Information Modelling (BIM)).	1	2	3	4	5
3	Availability of research data on sustainable building methods and green technologies.	1	2	3	4	5
4	Inclusion of education/training for operation and maintenance staff, and end-user.	1	2	3	4	5
5	Expressed interest and demand from clients.	1	2	3	4	5
6	Public awareness of environmental issues and benefits of using green technologies.	1	2	3	4	5
7	Public concerns on the quality and performance of green materials.	1	2	3	4	5
Governmental						
8	Enforcement of green building codes and regulations.	1	2	3	4	5
9	Complexity of government legislative procedures and requirements of submission documentation.	1	2	3	4	5
10	Governmental support or incentives (e.g., tax, special loans, and grants) for promoting green buildings.	1	2	3	4	5
11	Funding for research and the implementation of green construction projects.	1	2	3	4	5

No.	FACTORS					
12	Delay in approval of green building projects by local authorities.	1	2	3	4	5
13	Collaboration between developers and transport planning authorities.	1	2	3	4	5
Economic and Financial						
14	Information on opportunities and economic benefits of green buildings.	1	2	3	4	5
15	Availability of empirically proven cost data for green buildings.	1	2	3	4	5
16	Availability of green material suppliers.	1	2	3	4	5
17	Availability of locally sourced green building material.	1	2	3	4	5
18	Funding for construction.	1	2	3	4	5
19	Financial risks and uncertainties of rate of return of green investment and payback period.	1	2	3	4	5
Technical						
20	Use of conventional methods.	1	2	3	4	5
21	Use of green building techniques.	1	2	3	4	5
22	Incremental time required in green building design.	1	2	3	4	5
23	Lengthy approval process of design drawings.	1	2	3	4	5
24	Lengthy green material specifications.	1	2	3	4	5
25	Lack of knowledge of the appropriate procurement delivery method for green construction projects.	1	2	3	4	5
26	Slow tendering and procurement processes.	1	2	3	4	5
27	Effective planning.	1	2	3	4	5
28	Scarcity of contractors and subcontractors with green building experience.	1	2	3	4	5
29	Early identification and involvement of key project stakeholders.	1	2	3	4	5

No.	FACTORS					
30	Design flexibility against changes during the construction phase.	1	2	3	4	5
31	Inclusion of the contractor in the design development phase.	1	2	3	4	5
Social						
32	Implementation of health and safety management systems on site.	1	2	3	4	5
33	Community input for natural resources protection during site selection	1	2	3	4	5
34	Effective communication and engagement among project stakeholders (owner, designer, contractors, and end-users).	1	2	3	4	5
Environmental						
35	Reuse and recycling of construction materials.	1	2	3	4	5
36	Inclusion of water-saving initiatives on-site.	1	2	3	4	5
37	Implementation of a management plan for waste diverted to landfills.	1	2	3	4	5
38	Utilization of energy-saving techniques.	1	2	3	4	5
39	Finding a location-efficient site for a green building.	1	2	3	4	5
40	Implementation of effective stormwater management.	1	2	3	4	5
41	Use of land with low ecological value.	1	2	3	4	5
42	Other, please specify:	1	2	3	4	5

22. Do you have any further comments regarding the factors affecting the sustainable development, sustainability performance, and delivery processes of green construction projects?

Thank you for your contribution and time spent taking this questionnaire survey.