Cape Peninsula University of Technology

THE INFLUENCE OF A GREEN BUILDING CONCEPT ON THE VALUE OF A BUILDING

by

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DECLARATION

I, Faith Owoha, declare that the content of this thesis represents my own unaided work, and that the thesis has not previously been submitted for academic examination toward any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed **Date**

ABSTRACT

This study examines the influence of a green building concept on the value of a building. Comprehensive literature was carefully reviewed to provide an overview on the concept of *green building* and its influence on the value of a building, subject to its overall benefits in South Africa. Several studies have been conducted giving guidelines for the determination of the best capitalisation rates needed for valuing green building properties. However, the information is still inadequate in providing evidence of the relationship between green building features and its influence on the value of a building, leaving most buildings with green features undervalued. This is a peculiar concern this research seeks to bring to notice and with its limited scope proffer possible recommendations and conclusions.

A quantitative approach was adopted, facilitating the collection of data through the use of a questionnaire survey that involved randomly selected construction professionals in the Western Cape Province of South Africa. The motive behind the adoption of the quantitative method is to facilitate a reliable manner of satisfying the established aim and objectives for determining current practices in valuing green buildings. The above description paved the way for the use of theoretical, statistical and mathematical techniques for computation and interpretation of data to support objective reasoning and measures.

Data was analysed with the application of descriptive and inferential statistical analysis tools, wherein the mean values and one-way analysis of variance were carefully determined.

The findings demonstrate that the benefits of green building are critical for enhancing a building's value. The benefits are divided into tangible and intangible benefits to classify impact on a building value. The classification of the impact cut across reduction of the consumption of energy and water, lowering operating cost and developing flexible design options. Some of the significant features of the green building include water metering, a photovoltaic solar panel system, electrical sub-metering, high performance building façade and skylight and borehole water. Further findings indicate that *kitchen and water-closet (WC) water efficient fittings* is ranked highest with a mean value (MV) of 3.91, followed by *megawatt photovoltaic solar plant* with an MV of 3.79, and *water metering for monitoring and leak detection* with an MV of 3.74. In light of the MVs, it is evident that these features significantly influence the value of a green building. Subsequently, the features are classified as: *eco-friendly materials and energy conservation feature*; *water saving and renewable energy feature*; *safety feature*; *natural day light and control feature; sun shade and light feature; water management and flooring feature*, and *special utility feature*. Information as gathered in the study demonstrate that the current practices engaged in valuing green building projects do not specifically differ among construction participants, although the perceptions of construction professionals regarding the most significant green building features that enhance the value of a building is on the average.

Modalities towards promoting the concept and value of green building require resolute actions that should be implemented by the Green Building Council of South Africa. This concerns the creation of new growth strategies to escalate the awareness and implementation of a green building concept. Based on the benefits and significant features of green building, as determined through respondent affirmatives, this study broadens the view of construction professionals on the influence of a green building concept on the value of a building in South Africa.

Keywords: benefits, green building, green building features, South Africa, value

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BRM	Biometric Reader System
BSA	Building Sustainability Assessment
CFC	Chlorofluorocarbon
CIDB	Construction Industry Development Board
CMA	Comparative Market Analysis
DCF	Discounted Cash Flow
GBCSA	Green Building Council of South Africa
GB	Green Building
GWP	Global Warning Potential
GBC	Green Building Council
GBF	Green Building Features
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
KR	Kuder-Richardson Formula
LEED	Leadership in Energy and Environmental Design
LCC	Life Cycle Cost Savings
LCA	Life-Cycle Assessment
Low-E	Low Emission
LFG	Land Fill Gas
MV	Mean Values
MSW	Municipal Solid Waste
MLS	Multiple Listing Services
NOI	Net Operating Income
NBI	New Building Institute
ODP	Ozone Depletion Potential
PCA	Principal Component Analysis
PV	Photovoltaic
SABS	South African Bureau of Standards

SPSS	Statistical Package for The Social Science
SD	Standard Deviation
SIP	Structural Insulated Panels
TEWI	Total Equivalent Warning Impact
UPS	Uninterrupted Power Supply
VRF	Variable Refrigerant Flow
VOC	Volatile Organic Compounds
VRV	Variable Refrigerant Volume

CHAPTER ONE

1. Background of study

Buildings in their unique state are the main users of electrical energy, and thus play a critical role in contributing to global warming and the depletion of our natural resources (Saad, 2016:183). More so, the building construction industry is accountable for a high volume of pollution produced around the world (Saad, 2016:183). In a South African context, the operation of the building sector is responsible for 23% emissions of greenhouse gas, whereas emissions from the manufacture of major materials for the building sector adds to about 18mtCO_2 per year, or around 4% of the total CO_2 emissions (CIDB, 2009:3).

To prevent the environmental impact of climatic changes globally, it is necessary to investigate the environmental impact of buildings in South Africa (Gunnell, 2009:3) as this will expedite the swift implementation of correctional measures to avert more negative impact on the environment. In light of this, Saad (2016: 183) argues for a switch from conventional construction methods to adhering to green building concepts and methods. The concept of green building promotes energy saving, water saving and prudent use of material or resources in construction and building maintenance, with the aim of reducing or eliminating the unfavourable impact on the environment. It is quite clear that effecting the green building concept may result in reduction of water usage by 40%, energy usage by 50%, carbon emissions by 35% and solid waste by 70% (Bombugala & Atputharajah, 2013:20).

Green building in South Africa is regarded as a long-term business prospect since green building influences construction in both developed and developing economies. A global study conducted by Dodge Data and Analytics predicted that several international firms, including engineers, architects, specialist consultants, contractors and property developers, were concentrating on sustainable design and construction, as at least 60% of their projects were 'green' by 2018, following a rising trend of 28% in the year 2012 (Jones & Mandyck, 2016:5). For instance, it was anticipated that the percentage of construction firms in South Africa integrating green practices in their business was expected to increase from 27% in 2015, to an anticipated 61% by 2018 (Jones & Mandyck, 2016:10). Thus, South Africa emerged as one country with the highest green share among all the survey participants, indicating a market conducive to green building (Jones & Mandyck, 2016:11). As a result of this, the South African government and its private sectors are becoming increasingly aware of the need to practice construction in a sustainable way to protect the environment. The need for green building is evident, because the green building concept has influenced building value in countless ways over the years (Melissa & Shan, 2012:6). Meanwhile, the need or benefits of green building for forward-thinking building owners, operators, and tenants is clearer (Melissa & Shan, 2012:6).

In addition, a green building concept significantly aids a futuristic concept in nature, with the idea of creating a more sustainable living environment. Bilau (2008:31-32), however, contends that a green building concept as a global technology is faced with inadequacies attributed to the lack of integrated design, underscoring the reason behind the independent execution of task by workers until they are persuaded to work as a unit due to project overlap. Fundamentally, resistance to change and adoption of a new innovation yields risk and uncertainty. This implies that people are difficult to persuade to embrace change, especially when it involves the investment of capital. In that case, this intensifies and further promotes inadequacies across the systems and in valuing green building. As part of the process, it is important to note that green building will often increase building value through the use of more sustainable elements such as improved features and building materials involving aesthetics and finishing. Other considerable areas include a reduction of liability risk by lowering operating costs of a building or real estate portfolio and increments in the net operating income in huge ways.

Understandably, increasing net operating income increases a building's appraised value by ten times the annual cost savings (Mara & Bates, 2012:13). For example, from the use of moisture-control detailing, pollution and contamination rejection strategies, and ventilation tactics, green buildings are rendered healthier for occupants (Mara & Bates 2012:13). However, a clear understanding concerning green building and its corresponding value illustrates that these environmental controls share a parallel line of progress as the green building concept focuses on the value, sustained and guaranteed future, wellbeing and peaceful enjoyment by potential users. In that case, green building can have four components of value as stated by the Institute for Market transformation and Appraisal institute (IMT & AI, 2013)

- *Revenue* – Rental premiums are on the rise in many markets for green buildings, since well-informed tenants are inclined to pay premiums for green spaces (IMT & AI, 2013:2);
- *Occupancy* – As green building features lead to higher occupancy as compared with other similar buildings, occupancy premiums will, in turn, drive green investments. Thus, a relevant argument can be made for increases in value (IMT & AI, 2013:3);
- *Operating expenses* – In securing a green building, it is expected that other valuable incentives such as requirements for green certification (e.g. Energy Star and LEED), lower utility bills (derived based on improved energy codes), and well-effected retrofits.

Energy savings attained results in increased net operating income (NOI) and reduced operating expenses, suggesting positive effects on value (IMT & AI, 2013:4);

- *Risk* – in terms of risk-mitigating protections, the value of green building is considered among assets offer to banks and owners. In the underwriting and appraisal process, high-performance buildings protect changes in consumer preferences, uphold new laws and increase energy prices (IMT & AI, 2013:5).

This study focuses on the influence of a green building concept on the value of a building. As part of the study on green building, significant parameters like development and growth over time will be carefully scrutinised, along with control mechanisms and future sustenance of buildings by introducing the green building concepts to strengthen the protection of the earth and improve value. Integral to this study, basic requirements and techniques necessary for attaining a durable, adoptable, valuable and efficient green building to promote sustainable environment will be carefully investigated in order to ascertain the influence of a green building concept on the value of building.

1.1 Context of the research

Miller and Buys (2008, as cited by Elaine, 2013:10) describe the concept of a *green building* as a paradigm where 'green' is considered as a structure which throughout the various phases of building lifecycle, has potentially low environmental impact. This applies to design, construction and operation, and buildings that provide health and wellbeing for occupants. Fundamentally, the concept of a green building is expected to stimulate less energy consumption; by so doing, it will generate lower CO_2 emissions.

However, the description of a *green building*, as expressed by Lutzkendorf and Lorenz (2007:60), is enlarged beyond the narrow concept of lowering energy consumption level of a building as green buildings are constructed with a creative, higher urban planning, including functional and technical quality. Elaine (2013:12) identifies additional benefits of a green building concept as an increase in energy efficiency, lower operating and maintenance costs, provision of improved comfort and wellbeing for occupants, and more marketability than conventional buildings – primarily because of its uniqueness and sustainability qualities facilitating lower risk potential and reducing the detrimental impact on the environment.

Saad (2016:6) explains that several basic challenges encountered in the practice and implementation of a green concept were determined through the findings and discussions attained from private sector clients. In addition, further observations indicate that four factors were frequently ranked at 100% including lack of adequate knowledge as concerning green building and lack of information with regard to its benefits – which promotes inconsideration on the part of the builders towards the end-users and cost efficiency of a green building (Saad, 2016:6). In contrast, several factors were frequently ranked at 50%, including inadequate building regulations and lack of stakeholder buy-in to the technology (Saad, 2016:6). Moreover, other findings suggest that green building should not only be directed toward minimising the negative impact, but rather be considerate toward the positive impact of building on both indoor and outdoor environments (Gunnell, 2009:4).

McHarg and Van (2008, as cited in Gunnell, 2009:1) provided a clear understanding on other significant benefits of adopting green building, stressing that the adoption of a green building incorporates some basic principles and approaches that significantly influence the value of a building. These principles and approaches include sustainable maintenance building design and operation, sturdy and disaster resistant building, designed and built for long service life and future proof building, with flexibility towards any change in terms of structure and technology upgrade (McHarg & Van, 2008; Gunnell, 2009:1).

1.2 Problem statement

Several studies have been conducted to generate guidelines for the determination of the appropriate capitalisation rates required in valuing green building properties. The focus has always been to determine the actual value of a building considering mostly similar properties in the market using the market comparism approach, the profit method and so on. Presently, however, the information is still inadequate in providing evidence of the relationship between green building features and its influence on the value of building. This peculiar concern is what this study seeks to bring to light, though with limited scope, this study proffer possible recommendations and conclusions that can help with the consideration of the influence of a green building concept on the value of a building.

1.2.1 Sub problems

1. There is little or considerably low awareness of the relative benefits of a green building.
2. Only inadequate mechanisms are in place for determining the most significant green building features that impact the value of a building.
3. Due to the specialised nature of green building features, there are frequent challenges in determining the extent of influence green has on the value of a building.
4. Due to the ever-advancing technologies and relative inconsistency with green concepts, there are possible difficulties with identifying the current trend of green technologies adopted within the building industry for the construction of green buildings.
5. Due to the inconsistency with the practice of valuing green building, there may be potential difficulties in determining the value of a green building.

1.3 Hypotheses

1. There are significant differences amongst the perceptions of construction professionals regarding tangible and intangible benefits of green building.
2. There are significant differences between the perceptions of construction professionals regarding the most significant green building features that enhance the value of a building.
3. The perceptions concerning the current practice for valuing green building projects do not differ among construction participants.

1.4 Aim of the study

The aim of this study is to examine the influence of a green building concept on the value of a building as well as current practices for valuing a green building.

1.5 Objectives of the study

The objectives outlined below were developed to guide the attainment of suitable answers or outcomes for the research questions through practical methodology:

1. to examine benefits of green rated buildings within the building construction industry;
2. to identify and categorise the most significant green building features that enhance the value of a building;
3. to determine the extent to which green building features influence the value of a building;
4. to identify the current trends involving green technologies adopted by the building industry for the construction of green buildings, and
5. to identify current practices adopted to value green buildings.

1.6 Significance of the study

This study explores the concept of green building and the influence of 'green' on the value of a building. Since the introduction of this concept in South Africa, only a few contextual studies have been carried out in an effort to substantiate the influence of green building features on the value of a building. However, previous studies focused mainly on the barriers to green, green building legislation and cost benefits analysis of a green building (e.g. Hoffman & Cloete, 2014:67; Nurick & Cattell, 2013:92; Hoffman & Cowie, 2014:3; Cruywagen, 2013:79-80; Windapo & Goulding 2015). In view of this, this study will be extending its investigation into the prevailing challenges, the benefits, and the significant features of a green concept as it enhances the value of a building. This is because green building features can often be passive and implicit, making it less considered in the actual value determination of a building, hence the need for this study.

A green building, however, is geared towards creating a better economy, utility, durability and comfort. It is a construction project that is built to qualify for certification under any acknowledged global green rating system (Bernstein & Mandyck, 2013:5). 'Green' is an approach wherein adequate, sustainable, environmentally suitable habitation will be attained and promoted for the health and welfare of the inhabitants. Other important areas to investigate concern lack of proper knowledge surrounding green concept or technology, the high cost of construction and maintenance on green building, the absence of documented information on green concept, green benefits, and the influence of green on building value (Saad, 2016:6). Within the context of this study, several aspects of the concept of a green building – such as its technology, benefits, influence, and application in raising building value – will be discussed to determine its relevance in the construction industry within South Africa.

1.7 Research methodology

A concise introduction of the research approach adopted in this study is discussed in this section. From a clear understanding of the research context, a quantitative approach is adopted to substantiate the importance of the study objectives by defining relevant variables and initiating variable measurement; by defining the dimensions and metrics, statistical exploration and mathematical formulation; by numerical analysis of data collected through questionnaires, surveys or polls; or by manipulating pre-existing statistical data using computational methods to reach reliable conclusions (Monfared & Derakhshan, 2015:2).

The motive behind the adoption of the quantitative method is to facilitate a reliable manner of satisfying the established aim and objectives for determining current practices in valuing green buildings, examining the benefits of green rated buildings within the building construction industry, determining the degree of impact of green building features on the value of a building, and identifying the current trends involving green adopted technologies. The above description paved the way for the use of theoretical, statistical and mathematical techniques for computation and interpretation of data to support objective reasoning and measures.

1.8 Population and sampling method

The quantitative approach adopted in this study facilitates the consideration of the population and sampling method used, with the intention of identifying the appropriate relevant participants for the collection of required data leading to clear interpretation. In the process, the relevant professionals in the area undergoing study were appropriately selected to stimulate a practical means of attaining relevant data and findings in regard to the focus area. In this case, the group of the selected participants includes sustainability experts (green building designers and consultants), property valuers, architects, project managers, quantity surveyors, engineers, urban and regional planners and property developers.

Sampling is simply a fair generalisation of results by the researcher, given a selected population, involving a process of selecting units (e.g. people, organisations) from a population of interest, having studied the sample (Dawson, 2002:79). Sampling methods may be classified as *probability sampling* and *non-probability sampling* methods. From a simple description, a probability sampling method involves drawing randomly from the wider population to perform a decision in relation to a particular study to attain a study verdict applicable to the wider representation of a population (Cohen *et al.,* 2007:110). Contrarily, the non-probability sampling method does not involve the process of random selection (Singh, 2007:107; Rubin & Baddie, 2009:132). Literally, this means that the participant sampling is purposely selected (Singh, 2007:107; Rubin & Baddie, 2009:132). For the purpose of this study, the probability sampling method was adopted. The specific method used is the *simple random sampling technique.*

1.9 Data collection method

The data for this study were obtained from both *secondary* and *primary* sources. In this study, *primary* data was gathered through surveys with the aid of structured questionnaires. In contrast, *secondary* data consists of the review of relevant literature such as *inter-alia* construction journals, textbooks, reports and other valid publications that contributed significantly to the achievement of the aim of the research.

1.9.1 Data analysis

For the purpose of this study, the researcher adopted descriptive and inferential statistical techniques to analyse the data collected, a selection attributable to the nature of the data gathered from the surveys. In essence, this data required descriptive statistical analysis to quantify the distribution of data values across the variables, while inferential statistics were applied to determine the hypothetical and significant in terms of evidence and reasoning to foster facts and inferences that may be present in the study.

A descriptive statistical technique involves processes, practices, beliefs, conditions, relationships or trends invariably relevant for the study (Salaria 2012:1). Descriptive statistics are used in describing the central tendency of a data set analysed for a clear understanding of the data distribution identified around the three measures of central tendency: mode, mean and median (Henn *et al.,* 2009:44). Aggarwal (2008:1) defines *descriptive statistics* as a way of describing a scenario or real-world problem through numerical calculations, graphs or tables. Conversely, *inferential statistics* are defined by Aggarwal (2008:1) as statistical techniques used to test hypotheses and draw conclusions based on the probability results obtained from an inferential random sample.

In addition, statistical techniques can also be applied to test whether descriptive results are characterised by random factors or a real relationship (Aggarwal, 2008:1). Essentially, this method guides researcher decisions to determine if relationships exist between various sets of statistical results. More so, inferential techniques, as expressed above, will be highly useful in drawing inferences and predictions from a sample population of participants such as architects, valuers, quantity surveyors and others involved. The aforesaid statistical techniques are adopted to clarify the importance of the objectives of this study.

1.10 Ethical considerations

Ethical standards are duly observed to retain confidentiality for the names of the participants. There is no place in the research or survey documents where participant names are mentioned. Likewise, this study conforms to the ethical regulations pertaining to plagiarism by avoiding any form of unreferenced source. And furthermore, not a single participant will be paid for contributions as the study progresses.

1.11 Definition of terms

- *Green concept:* defined as an idea of using processes that are resource-efficient, environmentally structured and responsible throughout a building’s life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction (Howe, 2012:4).
- *Green building:* defined as a construction that represents the most efficient and least disruptive use of water, land, energy and resources; hence, it guarantees the healthiest environment (Alam &d Haque, 2016:1).
- Value: obtained from the advantage or use derived from an interest held in a property. It is an estimated amount payable in exchange for an asset or liability on a valuation date between a willing purchaser and corresponding seller of interest after appropriate marketing, wherein the parties acted knowledgably, prudently, and with no compulsion (Shapiro, Mackmin & Sams, 2012:3)

- *Green technology:* defined as technologies introduced into a building design to render a sustainable end product (Ahmad *et al.,* 2016:1). Innovation is the core characteristic of green technologies, involving systems and services, and sets of products that are constantly evolving.

- *Tangible benefits:* defined as benefits of a green building that include aspects of lesser operating cost, energy savings and reduced taxes. These are benefits comparatively easy to measure and monetise (Birkenfeld *et al.*, 2011:3).

- *Green building features:* defined are components or characteristics a building must possess in order to be referred to as 'green'. According to Salman (2019:1), an integral characteristic of a green building is its stress on protecting existing ecologies and improving ecologies that may have been damaged in the past.

- Intangible benefits: defined as benefits that may not be felt, but are relevant with respect to the value of a green building (Birkenfeld *et al.,* 2011:4).

1.12 Assumptions

1. It is assumed that green building features will add value to any building adopted as a sample in the course of this study.
2. It is assumed that the participants will answer the questions honestly and candidly.
3. It is assumed that the sample inclusion criteria are appropriate and thereby assure that the participants have all experienced a similar phenomenon as of the study.

1.13 Limitations

1. Based on the peculiarity of a green building concept and technology, the research may be limited in terms of its geographical location as there are not so many certified green buildings in the Republic of South Africa.
2. The concept of green building is a fast evolving one; hence, it is subject to constant changes in building methods. The researcher, though, is constrained by time limitations for this study and therefore cannot examine the plethora of changes.
3. Access to information concerning the inherent value of green features in buildings, including methods or approaches to ascertain such value differences, may pose a challenge as the concept of green building remains under study.

1.14 Research outlines

In this study, concise summaries of the chapters are outlined as follows:

- *Chapter One: Introduction* – this constitutes the background of the study, problem statement, sub-problems, significance of the study, research questions, research aim and objectives, study scope, study limitations, definition of terms, and ethical considerations, together with a theoretical and conceptual framework.
- *Chapter Two: Literature Review* – this chapter presents the review of relevant literature regarding previous research concerning the green building concept, factors that necessitate green buildings, green building features and their influence on building value, benefits of green buildings and building value.
- *Chapter Three: Research Methodology* – this chapter is comprised of the research methodology for attaining viable research findings through an appropriate interpretation of the research aim and objectives. Moreover, the chapter examines the sampling method, sampling strata, the data collection method and data analysis.
- *Chapter Four: Data Analysis and Discussion of Findings* – this chapter presents the report on the extracted data. In addition, the chapter interprets and discusses the analysed results in both graphical and tabular formats to clarify the relevance of the data to the study.
- *Chapter Five: Hypotheses Testing and Discussion of Findings* – this chapter consists of the testing of hypotheses and discussion of results as well as discussions of the findings in the context of the literature review.
- *Chapter Six: Conclusions and Recommendations* – this final chapter discusses the conclusions deduced from the findings which foster pertinent recommendations in accordance with the aim of the research.

CHAPTER TWO

Literature review

2.1 Introduction

This chapter discusses the relevance of previous work to this present research. The focus area for the study entails relevant discussion about the green building concept and its influence on the value of a building. Its major focus areas include the *concept of green building, prevailing challenges in adoption of a green building concept, and features of green building and how this influences the value of a building.*

2.2 Green building

The term *green building* refers not to specific buildings, but to the whole building life-cycle process, starting from conceptualisation, design, site selection, obtaining materials, construction, operations, and finally, commissioning. The term *sustainable construction* is often used to address the economic, ecological and social issues of a building in the context of its community (Gunnell, 2009:4). Howe (2012:4) defines *green building* as a practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle, from siting to design, construction, operation, maintenance, renovation and deconstruction. In addition, a *green building* can be further described as a technique adopted to improve building and site efficiency by using energy, water and materials to reduce building impact on human health and the environment through better siting, design, construction, operation, maintenance and removal of complete building life cycle.

Similarly, Alam and Haque (2016:1) define *green building* as construction that assures a healthy environment while promoting the most efficient and least disruptive use of land, water, energy and other resources. Mara & Bates (2012:6) asserts that a green building has more energy efficiency; even with the current global energy demand, green building is outgrowing current production. This signifies the importance of expanding the application of a green practice in South Africa. Howe (2012:4) adds that this practice complements the classical building design concerns of utility, durability, economy and luxury. Green building is also referred to as a *sustainable* or *high performance* building.

2.2.1 Green concept

Green concept has become one of the innovative trends in construction, as the value of a green technology or concept application in building construction is all-inclusive (Bombugala &

Atputharajah, 2013:20). This offers relevant merits when used in new facilities as well as existing structures (Bombugala & Atputharajah, 2013:20). A green concept renders buildings more energy efficient and sustainable because it possesses a lower carbon footprint and reduces the impact on the environment (Swarnkar & Singh, 2016:1). Ji and Plainiotis (2006:1) postulate that green building concepts are characterised by innovation, with a set of products, services and systems that are continuously evolving. In other words, a green building concept involves finding the balance between homebuilding and the sustainable environment. This requires close co-operation of the design team members, contractors and clients at all project stages (Ji & Plainiotis, 2006:1).

A green building concept complements the classical building design concerns of economy, utility, durability and comfort (U.S. Environmental Protection Agency, 2009:1). The basic goals of a green building concept are to provide attractive, comfortable, affordable shelter with minimal impact to the earth, whether by manufacturing or by application, thereby escalating building value (McHarg, 2005; Gunnell, 2009:4). Notably, builders, building owners, tenants and other associated professionals benefit from the application of green building concept (Advanced Control Corporation, 2017). As this development has given rise to the need for more sustainable approaches, it is primarily directed towards sustainability attributed to the concept's friendly environmental quality (Academy of Science of South Africa, 2014:32).

Mara & Bates (2012:6) posits that application of energy efficiency measures and a focus on sustainable practices are undeniably beneficial. In this manner, the building owners and operators who invest in green building strategies will be reducing the impact of climate change, preserving human life quality, improving business performance, and all the while adhering to governmental regulations.

2.3 Benefits of green building

2.3.1 Overview of tangible and intangible benefits of green building

According to Nalewaik and Venters (2008:2), green building yields a number of benefits to the owner, both tangible and intangible. Green building, also known as sustainably-designed buildings, benefits from lifecycle cost savings – including deferred replacement costs and improvements in human performance such as productivity gain, better health and an increase in prestige.

Birkenfeld *et al.* (2011:3) explain that the difference between tangible and intangible benefits is their level of influence and effect on the building and end users. These researchers contend that tangible benefits constitute reduced taxes, energy savings, lower operating cost and waste reduction (Birkenfeld *et al.,* 2011:4; Chen & Abualrejal 2015:501; Muhadi & Siswanto, 2001:3; Hema, 2012:34). All these parameters are relatively easy to measure and monetise. In addition, the researchers further state that intangible benefits, while not seen, are still considered pertinent to valuing a green building. Some intangible benefits include reduced environmental impact, improved company brand equity and goodwill, improved health of building occupants, and improved occupant comfort and productivity (Birkenfeld *et al.,* 2011: 4).

2.3.1.1 Tangible benefits and how these influence building value

Tangible benefits can be measured in monetary terms. All relevant examples, mentioned in the preceding subsection, are outlined by category below:

i. *Energy savings or efficiency:* This is referred to as the lesser energy used to provide the same quality of service (International Energy Agency, 2015). According to Chen and Abualrejal (2015:501), energy efficiency is the key to achieving sustainability in a green building. Lowering energy consumption in construction presents a significant opportunity for organisations. For instance, energy and costs of producing building materials, also referred to as a *lifecycle costs,* are attributed to a larger population and societal value of green buildings. Similarly, the purchase of a renewable energy from alternate sources and the purchase of carbon offset credits represent indirect holistic value. Nalewaik and Venters clarify that “greater public awareness and the corporate responsibility agenda are adding further corporate value to aspects of building sustainability that previously had to be judged solely on financial returns” (2008:4).
ii. *Lower operating cost:* Muhadi and Siswanto (2001:3) define *cost* as part of goods sold sacrificed in order to obtain revenue. Gupta *et al.* (2009:5) define *operating cost* as “the expenses relating to the operation of a business, or the operation of a device, component, or a piece of equipment or facility”. Based on preceding definitions, lower operating cost in green building is determined by reduction in cost associated with the maintenance and administration of a green building on a daily basis. The operating cost is deducted from the revenue to arrive at the operating income in a green building.
iii. *Waste reduction:* Green building seeks to decrease waste of water, energy and materials used during construction. In the process, one major target is the reduction in the amount of material ending in landfills. Well-designed buildings aid in the reduction of waste produced by occupants and the provision of on-site solutions. Another important usefulness of a green building is reducing the impact of waste on wells or water treatment plants. Such waste, regarded as *grey water*, derived from washing machines or dishwashing for example, can be used for subsurface irrigation, and perhaps if treated,

could be used for non-potable purposes, such as flush toilets and compost bins, washing cars and reducing matter going to landfills (Hema, 2012:34).

iv. *Maintenance savings:* Maintenance savings involves the design and selection of materials for building and site construction that result in lower maintenance costs and longer service life, thereby minimising the frequency of equipment replacement (Nalewaik & Venters, 2008:2). For example, native or inert landscaping conserves both water and monthly maintenance costs. Similarly, pollution prevention and waste management efforts reduce the ongoing cost of refuse disposal and treatment (Nalewaik & Venters, 2008:2). In addition, ongoing scheduled maintenance aids the reduction of utilities costs by properly caring for systems and equipment.

2.3.1.2 Intangible benefits and how these influence building value

Intangible benefits are relevant aspects of a green building that are not visible or touchable, but contribute to the use and value of the building (Birkenfeld *et al.,* 2011:4). As earlier stated, these types of green building benefits reduce liability and provide enhanced comfort, as discussed in this study.

i. *Enhanced comfort:* This particular characteristic of intangible benefit means reduced drafts and minimised floor-to-ceiling temperature stratification and control of noise. Furthermore, many green buildings enable strong control of individual spaces or offices. This heightens occupants' awareness of their own control over their workspace environment (Birkenfeld *et al.,* 2011: 4).

ii. *Reduced negative impact on the environment, improvements in human performance and productivity, improved company brand equity and goodwill, and improved health of building occupants* (Birkenfeld *et al.,* 2011:4): These aspects of design may focus on improvements in indoor environmental quality, such as air quality, temperature control and day lighting. Additionally, sustainably designed buildings, in terms of energy savings, have a positive effect on worker productivity and quality of life. Other vital contributions include occupant health and comfort improvement, stimulating the reduction of liability by lessening or eliminating toxic or harmful substances. This may also result in reduced absenteeism and turnover. Other improved areas include educational facilities, student retention and learning capability. While in the healthcare facilities, sustainable design may result in faster recovery time for patients. However, most results concerning the influence of sustainable design on building occupants are qualitative not quantitative (Nalewaik & Venters, 2008:4).

Other intangible benefits that influence the value of a building include the following:

- Design flexibility and careful consideration of site planning to reduce the square footage and associated systems (footprint) of the building, and right-sizing the facility while satisfying the needs of the owner (Nalewaik *et al.,* 2008:3).
- Efficiency in infrastructure: for example, minimised length of sewer and utility lines and savings on surface area for paving (Nalewaik *et al.,* 2008:3).
- Economised mechanical and electrical equipment, through the help of day lighting, natural ventilation and low- or no flow plumbing fixtures. Also, high efficiency systems and appropriate building siting are benefits (Nalewaik *et al.,* 2008:3).
- Use of locally-sourced or reclaimed materials, which not only boosts the local economy but also reduces transportation costs (Nalewaik *et al.,* 2008:3).

More so, aside from the aforementioned benefits of green building, there are other several benefits in sustainable environment and value, as mentioned Archana *et al.* (2013:70). These researchers contend that high performance green building emerged primarily to prevent pollution, and save energy, natural resources and money. They further claim an average estimate of 60% cost reduction in energy. Therefore, it is evident that people perform better during daylight, with provision of natural, non-glare light through the windows directly into the building.

Another kind of benefit is the reduction of respiratory diseases by 10 - 20%, and promotion good health for occupants because indoor air quality and occupant comfort is improved with the absence of VOC emissions from building materials. Green building is observed to increase productivity, and hence commands higher market value. Certain tax benefits are enjoyed, as the utility demands are often lower in green buildings. Green building "encompasses ways of designing, constructing, and maintaining buildings to decrease energy, water usage, and costs; and more so, to improve the efficiency and longevity of building systems, with the intention of decreasing the burdens that buildings impose on the environment and public health" Bombugala & Atputharajah (2010:21).

Other benefits attributed to value of a green building, as cited by Bombugala and Atputharajah (2010:21) include the following:

- Provision of healthier and more comfortable environments
- Improvement of long-term economic performance
- Incorporates energy and water efficient technologies
- Uses recycled material for its construction
- Reduces construction and demolition waste
- Incorporates renewable energy technologies
- Improves indoor air quality
- Reduces environmental impact
- Encourages greater tenant attraction
- Reduces vacancy periods

The above benefits stimulate points of interest for building owners and managers. These benefits have, in many ways, aided more tenants in observing environmentally friendly, sustainable, healthy and productive workspaces. Another cogent benefit of encouraging green buildings for the end-users is reduction in vacancy periods. This is because a tenant is liable to renew a lease, and if otherwise, new tenants are found quickly as a replacement. Additional reasons could be because green buildings are versatile in design and secure market value with less capital outlay. Companies wanting to demonstrate their corporate social responsibility are increasingly turning to sustainability initiatives (Bombugala & Atputharajah, 2010:21).

The ‘feel-good’ factor is another benefit of a green building. This involves social value – a compound function of public image, marketability, resource conservation and corporate responsibility. For certain owners, the ‘feel-good’ factor may tip the scales in favour of sustainability, where “choices being made to incorporate sustainability into design and construction are as a result of value the client sees in the economic and environmental benefits of green” (Zarchi *et al.,* 2012:90).

2.4 Features of green building

Green building is characterised by certain unique characters or elements that render it sustainable. One of the vital elements or characteristics of a green building is its resourceful use of energy, as this which incorporates many green features. For instance, if a building does not use energy efficiently, it is difficult to determine if it is truly green. With a high-performance building, for example, its environmental performance and energy efficiency is substantially better than standard practice (Howe, 2010:5). Outlined below are typical features of a green building, according to GBCSA (2019: online):

- Use of daylight censored high performance chilled water
- Economy cycle water recycling systems (e.g. rain water and grey water harvesting)
- Kitchen and WC water efficient fittings (e.g. censored taps, grey water collector)
- Recycled glass and steel
- Renewable materials like bamboo and rubber
- 3-pipe variable refrigerant flow (VRF) system
- Carpets made from 100% recycled material
- Wind energy (e.g. wind turbines and wind power plant)
- Photovoltaic solar panel system on building roof
- Megawatt photovoltaic solar plant
- Electrical sub-metering used for individual billing purposes
- Electric car and bicycle charging points
- Biometric reader system (BRM)
- Black water recycling system
- Water metering for monitoring and leak detection
- Vegetation efficient drip irrigation system
- Borehole water and reverse osmosis plant cyclist and shower facilities
- Use of roof light (e.g. tear drops)
- Use of inverters (a multi split air conditioner e.g. VRV III)–to enable individual zone control
- Recycled cork panels and flooring
- Use of sunglasses
- Triple-glazed windows
- Timber flooring from a certified plantation
- Atrium roof lights
- Use of light shelves
- Eco-friendly building materials,
- Environmentally friendly construction
- Green power
- Water use efficiency
- Energy efficient and eco-friendly equipment

Source: (GBCSA, 2019: online)

Resource efficiency

This can be achieved by utilising materials that meet the following criteria:

- *Renewable or plentiful, natural materials:* materials harvested from sustainably managed sources are preferable, as they have an independent certification (e.g., certified wood), and they are certified by an independent third party (Maeda, 2011:223).
- *Resource efficient manufacturing process:* with resource efficient processes, products manufactured include limiting energy consumption, reducing waste (recycled, recyclable, or source reduced product packaging), and reducing greenhouse gases (Hema, 2012: 33).
- *Recycled content:* products with identifiable recycled content include post-industrial content, with a preference for post-consumer content (Hema, 2012: 33).
- *Resource availability:* building materials, components and systems found locally or regionally that save energy and resources while being transported to the project site (Hema, 2012: 33).

2.4.1 Indoor air quality (IAQ)

Indoor air quality (IAQ) is a term that refers to the quality of air within buildings, in relation to the comfort and health of building users. In recent decades, a reasonable effort was expended in understanding the phenomenological aspect concerning IAQ and its human perceptions. Moreover, indoor air quality (IAQ) of a green building is considered, from design stage onward, as a unique feature since it can be affected by microbial contaminants (bacteria), gases (radon and volatile organic compounds, carbon monoxide), particulates, or any mass, even energy stressor that can induce adverse health conditions (Petrone *et al.,* 2012:227). Hema (2012:33) proposes certain criteria that enhance indoor air quality (IAQ) by utilising the under listed materials:

- *Non-toxic or low:* these are the materials that emit few or no carcinogens, reproductive toxicants or irritants as demonstrated by the manufacturer through appropriate testing.
- *Moisture resistant:* these are the products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
- *Systems or equipment:* these are the products that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.

2.5 Impact of green building features on the value of buildings

Buildings categorised as *green* have certain unique features that are introduced at various levels of design, construction and finishing, which include features enhancing durability, use and other functions as discussed earlier in section 2.4. Essentially, these features impact the value of a green building as a regular building compared to a more sustainable or high-performance building, thereby commanding more values. The impact of these green features on building value will be discussed at three levels, according to IMT and AI (2013), which include cost efficiency and optimisation, and quality in terms of material and usage.

2.5.1 Impact of green building features on building value in terms of cost

In many markets, rental premiums are emerging in green buildings as many of today's tenants are increasingly willing to pay a premium for green spaces, because green buildings provide healthy environments and lower operational costs, together with being an attractive property. In these cases, the enhanced marketability of the property gives investors or owners cause to increase prices. In some markets, green buildings are mainstreamed so that non-certified buildings can quote lower prices. Thus, leasing green space is an opportunity to demonstrate a commitment to sustainability, attract the best employees (and tenants) and improve productivity (IMT & AI, 2013:2).

Operating expenses: From this aspect, the most valued proposition of possessing a green building is lowering utility bills progressively realised from steadily improving energy codes, green certification requirements like LEED (Leadership in Energy and Environmental design) Energy Star and well-executed retrofits. The resultant energy savings reduces operating expenses while simultaneously increasing net operating income (NOI), a shift with positive effects on value. Furthermore, green buildings promote minimal energy and water usage, thereby reducing costs (IMT & AI, 2013:4).

Risk-mitigation: From this aspect, green building value is included in the risk-mitigating protection of the assets offered to banks and owners. In the assessment and underwriting process, green buildings may offer hedges against fluctuating consumer preferences, together with new laws and increasing energy prices (IMT & AI, 2013:5).

2.5.2 Impact of green building features on building value in terms of quality

The aim of incorporating green building materials is to construct energy-efficient structures (The Constructor, 2019: Online). The good quality of green building materials is what makes it this unique and an outstanding current technology: most of these materials are specified to the rating standards requirement. The materials are often eco-friendly, directly from natural sources. Example of such materials are bamboo, sips, insulated concrete forms, natural fibre floor, fibre cement, cordwood, straw bale, steel, thatch, composites, natural fibre and fibre glass, polyurethane, cellulose, cork, earth bags, slate/stone roofing, earthen materials, wood, polystyrene and isocyanurate, natural clay, non-VOC paints and stone. The life cycle of green building materials stresses durability due to a careful selection of environmentally sustainable building materials that optimally promote design. These qualities facilitate the incorporation of sustainable design principles into the construction of buildings by architects (The Constructor, 2019: Online).

2.5.3 Impact of green building features on building value in terms of usage

Occupancy premiums can top the case for green investments, provided that the green features result in higher occupancy than any other similar buildings (IMT and AI, 2013:3). In these cases, a significant argument is built for an increase in value, (IMT & AI, 2013:3). Superior features observed in green buildings exhibit an improved performance in the market, which leads to higher occupancy rates. This in turn provides investors or developers the relief of lower volatility in returns on investments. The most vital part is the lower cost at which green buildings are made available in the market, facilitating an upsurge in demand at affordable prices for end-users.

2.6 Mechanisms and information for determining the value of green building features

Value, as a vital parameter in evaluating green building features, is determined through its capacity to generate a certain quantity of service flow to meet the requirements of the owners or occupiers. However, concepts of value used in property valuation can either fall under the category of *market value,* which represents exchange value, or *worth,* which represents the use value depending on the purpose of the valuation. Thus, *worth* in this case, is defined as the value of the property to a particular investor, mainly for the purpose of investment, whereas *market value* is defined or shaped by competitive forces within the market, where property location determines the level of price offered for the asset exchange (Marrjanovic-Halburd, 2015:25).

Marrjanovic-Halburd (2015:25) asserts that the main objective of property valuation is to provide a financial measure of the function or service derived from the use and control of the given property. This process is guided by the international valuation standard (IVS), founded on three fundamental approaches. The first of the three approaches is called the direct comparison method (DCM), which specifically infers value by comparing properties to similar buildings; the second is the cost method (CM), which considers, in particular, the initial costs; and the third approach is called the income method (IM), which estimates net income generated through a direct capitalisation method or a discounted cash flow over an appropriate period (Marrjanovic-Halburd, 2015:25).

Traditional methods of valuation

2.6.1.1 Income method

The income method estimates the value of a property or building based on the income it generates. This type of traditional method of valuation is commonly used with apartment buildings or leasable space. Concisely, a capitalisation rate for the property in a given market is applied to the expected net income generated by the property to estimate the value. There are two different methods for determining this capitalisation value: direct capitalisation and discounted cash flow analysis (Goodman, 2014:1).

- *Direct capitalisation method*: This involves the attractiveness of the income capitalisation model, applying direct capitalisation in its apparent simplicity. This method requires the specification of two items, one year's income and the overall capitalization rate (Goodman, 2014:1). According to Lennhof (2011:79), the appraisal of real estate utilises five methods in developing an overall capitalisation rate in direct capitalisation, outlined as below:
  - derivation from comparable sales;
  - band of investment – mortgage and equity components;
  - band of investment – land and building components;
  - derivation from effective gross income multipliers and net income ratios; and
  - debt coverage formula (Lennhof, 2011:79).
- *Discounted cash flow analysis:* The discounted cash flow (DCF) is a cash flow summary that requires adjustment to reflect the present value of money. DCF analysis determines the present value of an individual asset or portfolio of assets. This is equal to the discounted value of expected net future cash flows, with the discount reflecting the cost of waiting, risk and expected future inflation. Also, DCF analysis is applied to investment project appraisal. Understandably, the combination of both the opportunity cost and risk yielded a discount rate for the analysis of the present value of anticipated future cash flows (Arumugam, 2007:8).

2.6.1.2 Sales/direct comparison method

The *sales comparison method,* also referred to as the *market approach*, estimates the value of a property based on a comparison of recent property sales in the same market area with similar characteristics. This approach is commonly used for single family residences, where there are typically many comparable sales and similar properties available to analyse (Goodman, 2014:1).

2.6.1.3 Cost approach

The *cost approach* estimates the value of a property based on the cost of building the property or the cost of replacing the property. This approach is most commonly applied to newly constructed buildings as it requires knowledge of the cost of construction and materials (Goodman, 2014:1). Shalley (2008:5) posits that while basic valuation principles still hold, one approach leads the way. Among other methods such as income method, comparison method, cost method, it is noted that the cost approach to value can be difficult to quantify because of the scarcity of green cost information currently available (Shalley, 2008:5). In addition, the market value of the real estate ‘in exchange’ versus ‘in use’ is the direct requirement for a given local property.

Green elements in any specified building would have to be evaluated, considering whether or not the market would pay a premium for the green components. Moreover, it is important to note that, though green building construction methods and their components are in early development the standards are changing rapidly. Green buildings, at this stage of their lifecycle, have more exposure for the re-evaluation of green products, high performance systems and accreditation standards that could potentially cause significant obsolescence in relatively new green buildings (Shalley, 2008: 5-6).

2.6.1.4 Building sustainability assessment (BSA) methods

According to Bragança *et al.* (2010:2012), the process of managing and accessing building sustainability in green featured buildings is executed by building sustainability assessment (BSA) methods. This can be oriented to different scales of analysis, building material, building product, construction element, independent zone, building and neighbourhood. In the process of analysing the scopes of sustainability support with the assessment systems and tools, three types of assessment methods must be properly distinguished (Bragança *et al.,* 2010:2012), enumerated below:

- systems to manage building performance (Performance Based Design);
- life cycle assessment (LCA) systems; and
- sustainable building rating and certification systems (Bragança & Koukkari 2010:012)**.**

2.6.1.5 Sustainability indicators

An indicator is expressed by value derived from a combination of different measurable parameters (variables). Moreover, indicators have to be defined in a clear, transparent, unambiguous way, even before addressing the concern of whether they relate and evaluate several parameters (Bragança & Koukkari 2010:013). The indicators are typically grouped, either aggregated or categorised, and other various aggregated indicators may lead to the formation of subgroups in a hierarchical system (Bragança & Koukkari 2010:013).

One of the main indicators of environmental sustainability is the assurance of the existing sustenance method of interaction between the human and his environment.

Economic development is another key indicator in sustainability, frequently referred to as *economic sustainability*. Put simply, an economic development with relatively insignificant environmental degradation or equitable developments that are environmentally and socially sound is referred to as economic sustainability (Bombugala & Atputharajah, 2013:20). An additional key indicator is *social sustainability,* which means that future generations should have equal or greater access to social resources as the current generation (Bombugala & Atputharajah, 2013:20). This is also an important source of information for determining the value of a green building and its features.

Hence, the sustainability indicators of the construction and real estate sector give information about the influence of the industry as a whole, and about the impact of the construction and operation of buildings and other built assets. Different approaches for indicators exist due to differences between societies, industrial traditions, environments and geography (Bragança & Koukkari 2010:012). The sustainability indicators for a building project can be selected from various lists prepared at by the government sector and communities. For a contractor or facility manager, it is important to differentiate between the criteria and tools for assessing technology at the global level, and the approach used at the site-specific application, or local level.

In spite of several differences between the lists of indicators, most of them deal with the key issues enumerated below:

- consumption of resources;
- environmental pressure;
- energy and water efficiency;
- indoor air quality;
- comfort; and
- life cycle costs (Bragança & Koukkari 2010:012).

Sustainable development is concerned with the capacity of natural systems in relation to the social challenges facing humanity (Băneş *et al.,* 2010:405).

2.7 Challenges of determining the value of green building features

In accordance with the investigation conducted by Shalley (2008:116) concerning the problems frustrating the determination of the value of green building features, some corresponding challenges were appropriately determined, as below:

- lack of feasible increment in sustainable design in some markets;
- inadequate data for evaluators to draw conclusions on the impact of green building features;
- inability to acquire necessary data since many green buildings are public sector properties, not built for investment purposes; and
- occupiers appear to reap more benefit from green buildings than owners or developers.

Appraisers are expected to improve the methods for addressing the aforementioned issues. The appraiser, for example, must understand the specific characteristics of green buildings, and by doing so, will be able to assess the impact of these characteristics on asset value.

Adomatis (2015:28) identifies a number of challenges in valuing green buildings. These challenges are itemised below:

- The impossibility of comparing ratings from numerous rating organisations, since different organisations adopt different *rating systems.*
- A lack of market data for valuers in valuing properties. In this case, a lack of data implies a lack of support in quantifying the value contributions of green building features, especially in a market with no transaction of a green building.
- Assessing green valuation by using existing databases incurs difficulties. In this case, incorrect evaluation of a green building could occur, for example, while the appraiser is reaching inaccurate comparison conclusions on a subject property supposedly confirmed green based on the multiple listing services (MLS) data. Actually, this problem will prolong an assessment period if green data in the MLS database is not improved.
- Residential properties constitute an entirely different set of problems due to the relatively recent emergence of properties with green features in the market.
- Private databases pose problems in valuing green buildings. Many of the green certified organisations generate a database of all the properties they have rated. Most of those organisations, however, retain this information as private and not for public use.

Developers and other decision makers may have contractors, subcontractors, materials and service providers lined up for traditional building or retrofitting. More so, moving to a green building may require new service providers, materials vendors, and the implementation of an integrated design process to aid the construction of a cost-effective green building.

Risk and uncertainty pose major challenges to determining value, even with investments and interest in green buildings growing rapidly for a host of complex and varied reasons. The financial case for green building is yet to firmly take hold in the real estate and development community. The risks in the real estate community regarding green buildings include the following:

- uncertainty over reliability of green building technologies;
- uncertainty over costs of developing green real estate;
- uncertainty of the economic benefits of a green real estate; and
- uncertainty about green building performance over time.

Further challenges, as pointed out by IMT and AI (2013), are outlined below:

- Market data problems;
- Markets with green sales data of residences with green features are a new occurrence in many markets. Some underwriters suggest that limited or no green sales indicate that green features have no value;
- The Appraisal Practices Board (APB) of the Appraisal Foundation issued a first exposure draft of a valuation advisory entitled *Valuation of Green Building: Background and Core Competency in 2013.* This advisory clearly addresses several potential issues relating to the valuation of green buildings;
- Assigning value, or no value, to green components without market support;
- Finding market support for influences on value, a difficulty encountered when using currently available database information, and determining the importance of culling green features from imperfect data;
- Overlooking green features. This could happen if the appraiser is not aware of the right features to look for and the right questions to ask;
- Using inappropriate adjustments that are not supported by paired-sales rent analysis, market interviews, secondary data or third-party research.

2.8 Current technologies adopted in green building

According to Ahmad *et al.* (2016:1), *green technologies* are the technologies that are incorporated into building design to make the end product sustainable. These consist of technologies that aid in production for saving energy (Lockwood, 2006; Mokhtar Azizi *et al.,* 2014); that is, water efficient and environmentally friendly technologies provide for good indoor environmental quality, and possess features for improving the economic, social and environmental performance of a building.

The variety of green technologies introduced in the construction industry depend on varying views of different researchers. The classification of green technologies, for example, is based on various project objectives, such as energy efficiency, indoor environmental quality enhancement, material efficiency, water efficiency, and operations and maintenance optimisation (Zhang & Platten, 2011:5). In addition, Roufechaei (2014:8) further classifies green technologies based on designer responsibility, such as architectural, mechanical and electrical. Then, Platten (2011:5) and Ahmad (2016:11) suggest that green building technologies be categorised under five primary groups that, while well-known to many researchers, are enumerated below with brief explanations:

- *Energy efficiency technologies:* This a group of technologies that reduce the amount of energy required to provide goods and services (Yang & Yu 2015: 113).
- *Water efficiency technologies:* This group of technologies is design to aid water saving initiatives. According to Zhang (2014:12), technologies such as water-saving appliances, decentralized rainwater technology, and greywater systems (water reclamation and reuse) greatly assist in achieving water efficiency in buildings and low-carbon communities. Basically, water-efficient technologies are important because they reduce the amount of water used in operating a building. Ahmad *et al.* (2016) present two-key technologies for conserving water in sustainable residential buildings: rainwater harvesting technology and water-efficient appliances and fixtures.
- *Indoor environmental quality enhancement technologies*: This refers to the green building technologies needed to efficiently complete a building project that provides enabling indoor environments for occupants. These environmental quality enhancement technologies include optimising building thermal performance, use of efficient type of lighting in terms of colour and output, application of solar chimney for enhanced stack ventilation, ample ventilation for pollutant and thermal control, application of indoor CO_2 (carbon dioxide) monitoring devices, and application of low emission (low-E) finishing materials (Zhang & Platten, 2011:13; Zhang & Shen, 2011:10).
- *Materials and resources efficiency technologies:* This group of technologies helps save scarce and non-renewable resources and materials. The material and resource efficiency technologies for green property development, as identified by Zhang and Platten (2011:11), include underground space development technology and use of environmentally friendly materials for HVAC, such as heating, ventilation and air conditioning systems.
- *Control systems:* This group of technologies is considered significant for the management of occupant preferences within a building environment, such as thermal and luminance comfort, energy conservation and indoor air quality (Dounis &

Caraiscos, 2009:6). Ahmad (2016:8) identifies six control systems for sustainable residential building designs: HVAC control, occupancy sensors, shading control, audio visual control, intercoms and security control. Also, Dounis and Caraiscos (2009:10) have determined that shading control is important for controlling the incoming natural light and solar radiation, as well as for reducing glare systems. Generally, these control systems are integrated and centralised, with software and hardware networks that are responsible for controlling and monitoring these indoor climatic conditions of a building.

2.9 Theoretical framework

The theoretical framework for the influence of a green building concept on the value of building is based on theories derived from literature reviews that can be employed to conceptualise the idea or innovation of green. This study will be adopting the 'innovation diffusion theory' postulated by Rogers, along with the 'sustainability theory' to understand the "influence of a green building concept on the value of a building". According to Rogers (2003:1), "*innovation* is the process of creating a new technology, device or procedure" while *diffusion* is the process of disseminating ideas, skills, concepts and knowledge through society. The 'innovation diffusion theory' (IDT) defines how "innovations or technologies become accepted and spread through large or small societies" (Rogers, 2003:1). Thus, a person acquires knowledge about an innovation to aid the application interpretation of the innovation (Demir, 2006:1).

According to Were (2015:26), the innovation diffusion theory is mainly applied in the adoption of innovations and it has a model identified as an innovation *decision model*. The application of this model signifies that the adoption of an innovation or a new technology, which propagates from a relatively small innovator segment to a broader innovator segment, is determined by critical factors: innovation perceived attributes; innovation-decision type; communications channels used by subsequent market segments; social systems with embedded innovation; and the extent of promotion efforts of change agents (Rogers, 1995:206; Yudelson, 2005:2). As the green building concepts, in particular, are simply considered innovations, the theory of adoption and diffusion can be used to conceptualise its value.

2.9.1 Conceptual frame work

Theories of sustainability, on the other hand, attempt to prioritise and integrate social responses with environmental and cultural problems. With a simple explication, an economic model integrates natural and financial capital, where an ecological model integrates biological diversity and ecological integrity, and finally, a political model improves social systems to realise human dignity. In literal terms, *sustainability* means a capacity to maintain some entity, outcome or process over time (Jenkins, 2009:380). Sustainability theory, then, can be conceptualised in the value of green buildings. Since green buildings themselves are all about sustainability, the concept revolves around environmental responsibility and resource efficiency throughout a building's life-cycle (Were, 2015:27).

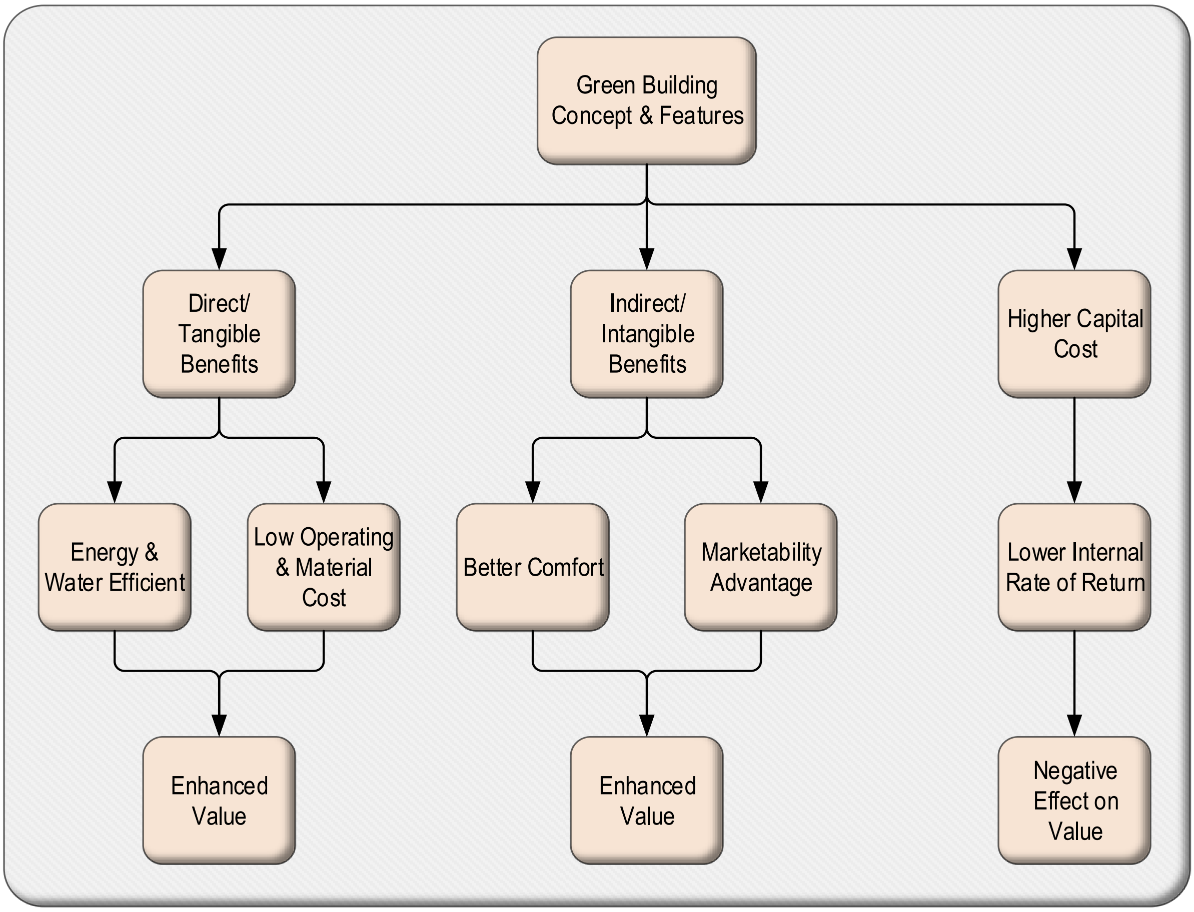

Figure 0.1: Illustrative diagram for conceptual framework

Figure 0.1 illustrates the conceptual framework of the concept of a green building and how it influences the value of a building. The process starts with the development of a green building concept and features three tiers: *direct/intangible benefits; indirect/intangible benefits;* and *higher capital cost.* Two of the three tiers yield energy and water efficiency, lower operating and material costs, better comfort, and marketability advantages for users, while the third one, *higher capital cost* on investment, detrimentally influences the value of a building that yields a lower internal rate of return. The end product of the process, as illustrated in the diagram, attains ‘enhanced value’ in the cases of *direct/tangible benefits* and *indirect/intangible benefits*, and suffers a negative effect on building value in the case of higher *capital cost*.

2.10 Chapter summary

This chapter reviewed literature relevant to this study, extending from the evaluation of the concept of green building, followed by the benefits of green building, together with the tangible and intangible benefits. Subsequently, the benefits of a green building and how it influences building value, considering the features of green building and the impact of these green building features on the value of a building were all reviewed. Moreover, mechanisms for determining the value of green building features with the traditional methods of valuation such as income approach, sales/direct comparison method, cost approach and building sustainability assessment methods were all discussed. Finally, the challenges of determining the value of green building features and the current technologies adopted in green building were discussed.

CHAPTER THREE

Research methodology

3.1 Introduction

Research methods are the tools and techniques for conducting research. *Research* is a term used for any kind of investigation intended to uncover interesting or new findings. The rigour at which this activity is executed will dictate the quality of the results (Walliman, 2017:1). A research methodology, therefore, offers opportunities and strategies for conducting a study. According to Leedy and Ormrod (2010:2), *research* is simply a systematic process of collecting, analysing and interpreting information with the aim of broadening the understanding of a specific interest, situation, or concern. Furthermore, Collis and Hussey (2003:100) assert that research methodology focuses primarily on the following: the reason a certain data was collected, what data was collected, where the data was collected, when the data was collected, how the data was collected, and how the data will be analysed. The research methodology adopted for the designated purpose of a study provides an overall scope for gathering and formulating the required data.

Leedy and Ormrod (2010:4) explain that selection of a research method should be founded on the nature of the data required in solving a real-world problem. This chapter discusses and explains the research design adopted in acquiring the data to be analysed. It also examines the sampling size and techniques, along with the data collection process, questionnaire design and questionnaire management. In addition, the techniques for analysis, hypotheses testing, and the reliability and validity of the instrument for data collection have also been outlined.

3.2 Research design

In this study, the scope of the study, collection and analysis of the data and emergence of the conclusions and recommendations are appropriately structured through the design of the research methodology. As stated earlier, it is imperative to understand the nature or type of data to be collected and presented for appropriate analysis in the process of solving any problem (Leedy & Ormrod, 2010:1; Leedy & Ormrod, 2010:5). Moreover, Leedy and Ormrod suggest that a pragmatic presentation pertaining to the data could be managed by fostering appropriate answers to the four principal questions itemised below (Leedy & Ormrod, 2010:5):

1. “Where is the data located?”
2. “How will the data be obtained?”
3. “How will the data be interpreted?”

4. “What data are needed?”

In this study, data relating to the influence of a green building concept on the value of a building will be gathered under the categories of these four questions.

1. *“Where are the data located?”* – Data will be collected by engaging with built environment professionals from both construction and consulting firms who are involved in green building practice in South Africa.
2. *“How will the data be obtained?”* – Data will be obtained through a well-constructed, self-administered questionnaire, with both open- and closed-ended questions that will be formulated and distributed to acquire necessary data.
3. *“How will the data be interpreted?”* – Data will be analysed and compared to the literature, with possible suggestions thereafter offered. Descriptive and inferential statistics will be used for data analyses.
4. “What data are needed?” – Data concerning the influence of a green building concept on the value of a building will be sought: the benefits of green rated buildings in the building construction industry; the most significant green building features that enhance the value of a building; the impact of green building features on the value of a building; the current trends of green technologies adopted by the building industry for the construction of green buildings; and the current practices in valuing of green buildings.

Conclusively, Leedy and Ormrod (2010:3) further state that research methodology must describe, in particular, the nature of the data collected and the method applied in processing the data to attain feasible findings.

3.2.1 Quantitative research

According to Bryman (2012:35), *quantitative research* can be defined as a research method that accentuates quantification in the gathering, interpretation and analysis of data. Furthermore, simple observations on quantitative research are outlined below:

- It involves a theory-testing process on the relationship between theory and research in which emphasis is placed on theory testing.
- It integrates the actions and standards of the natural scientific model, and in particular, that of positivism.
- It incorporates social reality from an external objective view (Bryman, 2012:35).

A quantitative research approach, then, is regarded as an approach beneficial in research to count and analyse data statistically and estimate the results in numerical forms (Gomm, 2008:2). Quantitative research designs include research surveys, developmental design studies, correlation research studies, observation methods, experimental methods and retrospective designs (Thomas, 2003:41). Leedy and Ormrod (2010:172) acknowledge that "quantitative research methodology seeks explanations and predictions that will be generalisable", although the purpose is to establish, validate or confirm relationships, and to develop generalisations that add to existing theories. Quantitative methods in this study seek to categorise and quantify the influence of a green building concept on the value of a building. Notably, Leedy (2010:179) identifies the following methods for properly conducting of quantitative research:

- theoretical studies;
- descriptive research;
- developmental studies such as case studies and surveys; and
- correlational studies.

To formulate questions in quantitative research, Flick (2011:7) identifies the following as fundamental concerns:

- researcher's understanding of how the questions will be formulated;
- type of questions to be formulated; and
- questions posed.

Similarly, Dahlberg and McCaig (2010:160) mention the vital points to be noted by a quantitative researcher in response to the questions below:

- What to ask?
- Why to ask?
- Who to ask?
- How to ask?
- What is the answer?

3.3 Population and sampling method

Fellows and Liu (2008:2) acknowledge that it is vital for a researcher to extract data from a portion of the total population, particularly in the area which concerns the study. This portion of the total population is known as *sampling*. In other words, sampling is the process of choosing units (that is, organisations or people) from a population of interest (Dawson, 2002:79). This initiative will aid the researcher's ability, after studying the sample results, to generalise the results fairly back to the selected population (Dawson, 2002:79). For this study, the selected population is comprised of construction professionals involved in the design and implementation of green building concept, including sustainability experts, green building designers, consultants, property valuers, architects, project managers, quantity surveyors, engineers, urban and regional planners and property developers.

Table 0.1 present the list of professionals and contractors, with their associated grades, that constitute the study population. Fellows and Liu (2008:2) affirm that an integral aspect of sampling is the determination of the size of the sample to be studied. Hence, the total population in this study is 1,610 (that is, 860 + 750) construction professionals. The information presented in Table 0.1 is accessed on eMagazine, as professions and projects register and the GBCSA official website; information in Table 3.3 is accessed on the CIDB official website.

Table 0.1: List of professionals in the Western Cape Province

List of professionals	Number
Green building professionals	223
Architects	324
Construction project managers	37
Engineers	148
Quantity surveying	128
Total	**860**

Source: Professions and projects register (eMagazine, 2018) and GBCSA official website (January, 2018)

Table 0.2: List of contractors registered with CIDB

Grades	Numbers
Grade 3	136
Grade 4	188
Grade 5	114
Grade 6	154
Grade 7	94
Grade 8	44
Grade 9	20
Total	**750**

Source: CIDB official website (January, 2018)

3.4 Sampling techniques

Babbie (1990) and Onwuegbuzie and Collins (2007:281) define *sampling* as an essential technique for enabling researchers to decide on the number of participants from which inference will be drawn, and the techniques to adopt in their selection (sampling method) due to time and cost constraints. The relevance of a sampling technique is to provide a practical means of facilitating data collection and data exploration processes in a study, while ensuring that the sample provides a good representation of the study population (Fellows & Liu, 2008:159). According to Leedy and Ormrod (2010:205), sampling can be categorised as either *probability sampling* or *non-probability sampling*. Kirk (2008:6) defines a *study population* as a group of all people, objects or events having one or more specified characteristics. The technique of probability sampling was adopted for this study.

Concerning probability sampling, the researcher can specify in advance that each segment of the population is represented in the sample (Leedy & Ormrod, 2010:205). Common forms of probability sampling include simple random, stratified, cluster, systematic and multistage sampling. In probability sampling, a sample from a larger population is selected using a method based on the theory of probability to ensure that each element of the given population is represented in the sample, but everyone in the population has an equal chance of getting selected, thereby necessitating this method.

To determine a suitable representative sample, the formula from Czaja and Blair (2005:146) and Creative Research Systems (2016: online, as cited by Ankrah, 2007:141; Akadiri, 2011:185) was applied as displayed below:

$$ss = \frac{z^2 \times p(1 - p)}{c^2}$$

Where:

ss = sample size;

z = standardised variable;

p = percentage picking a choice (expressed as a decimal); and

c = confidence interval, expressed as a decimal.

To achieve a sample size with a given degree of accuracy, the worst case percentage picking choice of 50% was assumed according to Ankrah (2007:142), Akadiri (2011:186) and Oyewobi (2014:112), and a 95% confidence level was assumed in other studies with a significance level of $\alpha = 0.05$; $z = 1.96$ at 95% confidence level; and a confidence interval (c) of ±10% was taken.

The sample size was computed as follows (Equation 1):

$$ss = \frac{1.96^2 \times 0.5(1 - 0.5)}{0.1^2} = 96.04 \quad \text{(Equation one)}$$

Thus, the required sample size for the questionnaire survey is 96 professionals. This figure is required to generate a new sample size from the research population using the following formula (Equation 2) as suggested by Czaja and Blair (2005:146):

$$\text{New } ss = \frac{ss}{1 + \frac{ss - 1}{pop}}$$

Where:

pop = population

pop = 1,610

$$\text{New } ss = \frac{96.04}{1 + \frac{96.04 - 1}{1610}} \qquad \text{(Equation two)}$$

$$\text{New } ss = 90.86$$

The above calculation put the sample size at approximately 91 professionals. Takim *et al.* (2004:1126) confirm that the response rate is assumed to be between 20–30%. Therefore, the sample size is expected to be adjusted to account for non-response. Assuming a conservative response rate of 20%, the appropriate sample size to be surveyed was calculated as follows (Equation 3):

$$\text{Survey } ss = \frac{\text{new } ss}{\text{response rate}} \qquad \text{(Equation three)}$$

$$\text{Survey } ss = \frac{91}{0.2} = 455 \text{ professionals} \qquad \text{(Equation four)}$$

Hence the sample size of 455 built environment professionals was obtained, and a simple random sampling method was adopted to select the survey participants.

3.5 Sources and collection of data

Data collection techniques entail the process of exploring a range of data sources to gather information for a research study (Struwig *et al.,* 2001:116). The choice of data collection adopted for a research study is directly dependent on the sample frame, nature of the sample, research topic and the facilities available for data collection (Leedy & Ormrod, 2010:210). The data types collected in a research study are both secondary and primary data (Struwig *et al.,* 2001:116). Similarly, the source of data collection is categorised into secondary and primary data sources.

3.5.1 Secondary data source

This consists of the review of existing literature relating to the research area. *Secondary data* are data readily available and accessible, obtained from research conducted by other researchers (Struwig *et al.,* 2001:119). According to Naoum (1998:1), "literature review involves reading and evaluating what other people have written with regard to one's subject area, both descriptive and analytical". A descriptive form of literature review describes the work of previous writers, while an analytical form of literature review critically examines the contribution of others with the intention of identifying similarities and contradictions of previous writers. Kumar (2005:170) asserts that a review of literature serves to improve and consolidate the researcher's knowledge base and assists in integrating the findings with the existing body of knowledge. For the purpose of this study, literature of others who have researched green building, its value and valuation methods, application and implementation, was consulted. A preliminary literature review related to the influence of a green building concept on the value of a building was undertaken to gain insight into the proposed objectives.

Dahlberg and McCaig (2010:53) posit that the review of literature enables a researcher to explore the depth of evidence that has been gathered within a research area and reveals areas that are under-researched; O'Leary (2013:152) also notes that for new knowledge to be generated, it is vital to consult past innovations. Hence, an extensive literature review was conducted to develop a comprehensive and coherent view of the salient topics, such as the benefits of green building, green building features and their impact on the value of a building, current technologies adopted in green building, and current practices adopted for determining the value of a green building. The sources of information compiled for the literature review included textbooks, Internet, journals, conference proceedings, round table discussions, dissertations and theses.

3.5.2 Primary data source

Primary data are new data generated for a research project (Struwig *et al.,* 2001:118). Struwig and Stead (2007:80) describe primary data as new data, generated for the research study, involving sources that collect data by direct, detached observation, or measurement of phenomena in the real world, undisturbed by any intermediate interpreter. Primary data are considered the most valid information obtained in a research (Leedy & Ormrod, 2010:211). Moreover, Leedy and Ormrod (2010:89) emphasise that "primary data are often the most valid, illuminating, and most truth-manifesting". Similarly, Wegber (2009:26) quite simply defines *primary data* as information captured at the point where it is produced. A questionnaire survey was adopted for this study, in which closed and open-ended questions were developed to solicit respondent opinion pertaining to the influence of a green building concept on the value of a building.

3.5.3 Questionnaire design

Leedy and Ormrod (2010:170) define *questionnaire* as an instrument that enables data collection beyond researcher's physical reach, without seeing the source from which the data has originated. A questionnaire is, therefore, a totally impersonal probe. Due to this impersonality associated with questionnaires, a questionnaire needs to be governed by certain practical guidelines. Firstly, the language must be simple, robust and comprehensive so as to avoid presenting irrelevant information to the respondent. Secondly, questionnaires should be designed to fulfil a specific research objective, as questions can often be clumsily written (Leedy & Ormrod, 2010:227), and if so, tend to result in seemingly low response rates (Leedy & Ormrod, 2010:227). Moreover, Fellows and Liu (2008:153) add that questionnaires should be unambiguous and uncomplicated for the respondent to answer. More specifically, questionnaires should not require extensive data gathering by the respondent to facilitate questions answering. The questions for this study's survey, formulated according to the research objectives and hypothesis, were comprised of three sections: background information of the respondents, benefits associated with a green building, green building features and the impact of these on the value of a building.

Section A of the questionnaire elicited information on the profiles of the respondents (Appendix B). The information gathered included the highest qualification, occupation of the respondent, length of time worked in construction, involvement in green building by respondent's organisation, and how regularly a green building concept was used. Similarly, section B elicited information concerning the benefits associated with green building, where each information was measured using a Likert scale ranging from 1 to 5. The Likert scale, dimensioned as follows: 1 = minor extent, 2 = near minor extent, 3 = some extent, 4 = near major extent, and 5 = major extent, was further classified into tangible benefits and intangible benefits of a green building.

Table 0.3: Questionnaire design

Section	Title	Objectives to be addressed
A	Background information of respondents	Identify current practices in valuing of green buildings
	Awareness, adoption and implementation of green building concept by organisations	

B	Benefits associated with green building	Ascertain the benefits of green rated buildings in the building construction industry
C	Green building features and the impact on the value of a building	Identify and categorise the most significant green building features that enhances the value of a building.
		Determine the extent to which green building features impact on the value of a building
		Identify the current trend of green technologies adopted by building industry for the construction of green buildings

Section C, the final of the three questionnaire sections, collected data from respondents on green building features, and its impact on the value of a building. Each was measured using a Likert scale ranging from 1 to 5, dimensioned as 1 = least important, 2 = not so important, 3 = neutral, 4 = important, 5 = most important, and 0 = unsure. It is important to note that the impact of green building features on the value of a building was further categorised as potential impact on cost, quality and usage. This section also evaluated the current technologies adopted in green building, with each factor evaluated using a Likert scale ranging from 1 to 5. The Likert scale was dimensioned as 1 = not effective, 2 = not so effective, 3 = neutral, 4 = effective and 5 = very effective. Also, the methods for valuing green building were considered under this section, each method evaluated using a Likert scale ranging from 1 to 5, where 1 = not effective, 2 = not so effective, 3 = neutral, 4 = effective and 5 = very effective (

Table 0.3 above). Fellows and Liu (2008:153) identify two forms of questionnaires which are open- and closed end questionnaires, both of which were formulated to collect data.

Open-ended questionnaire

According to Fellows and Liu (2008), an *open-ended questionnaire* is designed to enable the respondent to answer the questions fully by answering in any manner and to any extent the respondent chooses. Furthermore, the motives, expectations and true feelings of the respondent surface when open-type questions are asked. However, Struwig and Stead (2001) clarify that open-ended questions may demand a difficult and time-consuming tabulation of responses. The open-ended questionnaire was useful in addressing aspects of personal or professional experiences of the participants. Examples of open-ended questions are as follows: Due to the specialised nature of green building, do you often encounter challenges in the execution and implementation of the concept? Can you specify techniques adopted in your profession for easy determination of the value of green building features? Do you have any comments in general regarding the influence of a green building concept on the value of a building? These open-ended questions enticed participants to share from their work experiences matters relating to determination of value of green building features, the influence of green building concept, and possible challenges encountered during the implementation of green building concept.

Closed-ended questionnaire

A closed-ended questionnaire allows one to limit the number of responses by offering specific alternatives from which the respondent must choose, generally one or more. It simplifies the recording, tabulation and editing process considerably (Struwig & Stead 2001). Furthermore, as closed-type questions are exact and to the point, responses tend to be clear, enabling easy grouping and quantifying of responses of a similar nature. Fellows and Liu (2008), however, claim that closed-type questions force respondents to make artificial choices because the questions may be rigidly structured.

The use of closed-ended questions was also useful in aspects of retrieving specific information regarding the study. It aided in the use of ranking and scaling questions with multiple options and direct questions such as the following: Has your firm/organisation ever adopted the use of green building concepts, on a scale of 1 (least important**)** to 5 **(**most important)? Based on your professional practice, what aspects do you think have the greatest potential impact on the value of green building? These questions were useful in aspects of general adoption, awareness of green building concepts and specific use of the concept of green building.

3.5.4 Survey administration

Fellows and Liu (2008:153) state that questionnaires may be administered by post or email to respondents, to groups, and personally, to particular individuals. The questionnaires were administered in two ways: by email and by hand-delivery. Considering the distribution by email, the addresses of construction professionals from different companies and individual experts in construction were acquired through the professions and projects register database, websites of the Green Building Council and CIDB, along with friends and others making recommendations. The survey administration processes are presented in
Table 0.4.

Table 0.4: List of survey administration and activity

Survey administration	Dates
Initial survey launched	6th August, 2018
First email reminder	20th August, 2018
Last email reminder	27th August, 2018

Table 0.5 makes evident that respondents responded swiftly to the questionnaires distributed by hand, more so than the questionnaires distributed through email. This may be attributed to the busy schedules of the selected participants, or other reasons such as workers on leave from office, no longer practicing with the firm, of lacking adequate information on green building technology. 'Monkey survey' was also adopted to make the process easier for the respondents although the use of monkey survey did not yield positive outcomes due to its lack of conformity or suitability to the research study. During the exercise, email reminders were sent out to the participants to ensure optimal feedback.

Table 0.5: Survey activity and responses

Survey activity	Hand-delivered	Email
Dispatched and sent	66	389
Responses received	60	47
Responses not-received	6	342

In addition, further clarification shows that the survey was initially launched on 6th August, 2018, and first email reminder was sent out to respondents some few days (20th August 2018) after the initial launch to follow up. The last email was sent to respondents on the 27th of August, 2018, to ascertain the level of responses and the closure of the survey exercise. By the end of exercise, a total of 107 positive responses were gathered and 348 were either failed responses or response at all.

3.5.5 Response rate

The *response rate,* also known as *completion rate* or *return rate*, is the number of respondents who completed the survey divided by the number of people in the sample. It is usually expressed in the form of a percentage. Based on the survey conducted, the population was 1,610, and the sample size 455. The number of respondents who completed the survey totalled 107. Therefore, the estimated response rate is 23.52%. The estimated value is considered acceptable because it falls within the specified range of 20-30% (Takim *et al.,* 2004:1126).

3.6 Data Analysis

Data analysis includes testing, tabulating, categorising and examining results to address the purpose of a study (Yin, 2003:103). In this study, quantitative analysis was used in examining the nature of the data collected. The quantitative data obtained from the structured questionnaire were analysed and encoded using Statistical Package for the Social Sciences (SPSS) 25 software and descriptive statistics. Frequency tables and graphs were drawn from analysed data and presented accordingly.

3.6.1 Descriptive statistics

Descriptive statistics refers to the act of describing or summarising quantitative data obtained in a study in a meaningful manner and understandable format (tables and charts, for example) (Lapan & Quartaroli, 2009:75). It also provides an overview, a coherent and straightforward picture of a large amount of data. To buttress the above, Struwig and Stead (2001:150) mention that descriptive statistics provide statistical summaries of data. Henn *et al.* (2009:44) identify the three measures of central tendency as mean, median and mode. The study variables are broadly described with mean values and respective percentages of the respondents. This study adopted mean, percentage and standard deviation in analysing the quantitative data obtained in the survey.

Mean (average)

Mean, the most common measure of central tendency, refers to the average value of a group of numbers. Statistically, the average or mean value is calculated by dividing the summation of all scores by the total number or counts of all scores (Sykes *et al.,* 2016:6), calculated from the formula below:

$$\frac{\sum X}{N}$$

Where:

ΣX = summation of all scores in the distribution; and

N = total number or counts of all scores.

Hence, the mean ranking was used in this study to rank the degree of importance of the benefits of green building concept; it was also for ranking the features of green building and the impact on the value of a building. Green building technology and method of valuation was also ranked using the mean.

3.6.1.1 Median

Median is another central tendency measure for in calculating the distribution of data across variables. Half of the data distribution is above the median and half are below it, only after the data are arranged in numerical order from the highest to the lowest values. As the central value, the median is useful if there is an extremely high or low value in a collection of values (Sykes *et al.,* 2016:6).

3.6.1.2 Mode

Mode is the most frequent or common score in the distribution, the point or value of X that corresponds to the highest point on the distribution. If the highest frequency is shared by more than one value, the distribution is said to be multimodal**,** and will be reflected by peaks at two different points in the distribution (Sykes *et al.,* 2016:6).

3.6.1.3 Standard deviation

Standard deviation provides insight into magnitude of variation in distribution within a group of values, measuring the deviation (difference) from the group's mean (average). The standard deviation (s or σ) is the positive square root of the variance. The variance is measure in squared units, with little meaning to the distribution of data. Thus, the standard deviation is a measure of variability expressed in the same units as the data. The standard deviation operates in same way to the mean or an ‘average’, but only determining the deviation in the distribution of data around the average value (Sykes *et al.,* 2016:6).

3.6.2 Inferential statistics

Inferential statistics, using samples of observations to infer observations found in a population, assist in generalising findings from a sample to a larger population (Struwig & Stead, 2001). According to Kothari (2004), inferential statistics refer to a variety of tests performed in determining the validity of data, with the aim of reaching conclusions. Two inferential statistics test analyses considered in this study for validating data integrity are *factor analysis (FA)* and *analysis of variance (ANOVA)*.

3.6.2.1 Factor analysis (FA)

According to Pallant (2011:181), factor analysis (FA) incorporates a variety of different but related techniques employed in reducing a large set of variables to aid the selection of smaller sets of factors or components. Hair *et al.* (2010:11) describe FA as a multivariate statistical technique for examining the underlying constructs, or the structure of interrelationships within a large number of variables. The basic motivation for using FA, according to Lei (2009:505), is to aid easy reduction of a large data set to a fewer number of uncorrelated latent factors that will account for intercorrelations of the response variables. This is to deter the presence of latent factors from the response variables, and afterwards, a dataset with no remains of any correlations between a given set of response variables. Moreover, Pallant (2011:182) further adds that *sample size* and *strength of a relationship between variables* determine the degree of appropriateness of a group of data for FA purpose.

With further clarification, two different researchers have proffered similar arguments, but with differing conclusions in terms of the appropriate sample size to consider for FA purpose. Hair *et al.* (2010) acknowledge that a sample size of 50 is acceptable, but with 0.75 factor loading; while Field (2013:684), alternatively, claims that a sample size below 100 with commonality greater than 0.6 is perfectly acceptable. Nevertheless, there is a slight agreement amongst researchers on the exact magnitude of a sample subject to an FA and *principal component analysis (PCA)* (Cattell, 1978; Comrey & Lee, 1992; Hair *et al.,* 1979; Mundfrom *et al.,* 2005; Tabachnick & Fidell, 2012:618). In addition, Tabachnick and Fidell (2012:618) specify that sample size in the range of 100-200 is acceptable for PCA. The two researchers further clarify that sample sizes below 100 are acceptable, while cautioning that such small samples run the computational risk of failure of the solution to converge (Tabachnick & Fidell, 2012:618). Ultimately, with a clear understanding, we can assert that there is no one acceptable sample size for FA and PCA. In that case, it is advisable to consider a sample size above 100. In this study, for example, the computed sample size is 107, more than 100, indicating that the sample size is adequate for FA and PCA, as suggested by Tabachnick and Fidell (2012:618).

3.6.2.2 Testing of the hypotheses using ANOVA

In this study, hypothesis testing is crucial in determining the behaviour of variables or phenomenon under the investigation. Two researchers, Leedy and Ormrod (2010), state that a research hypothesis possibility will originate in the sub-problems, and a one-to-one correspondence often exists between the sub-problems and their corresponding hypotheses. A hypothesis provides a position from which one may initiate an exploration of the problem or sub-problem, simultaneously acting as a checkpoint against which to test the findings that the data reveal. Leedy and Ormrod (2010:12) offer this definition: *"hypothesis is a logical* *supposition which provides a tentative explanation for a phenomenon under investigation"*. Hypotheses are either supported or not supported by the data. The validity of the hypotheses in this study was tested by means of ANOVA.

Table 0.6: Statictical hypothesis testing

Hypothesis	Statistical test
There is a significant difference between the perceptions of construction professionals on the tangible and intangible benefits of a green building.	FA, reliability test, and ANOVA
There is a significant difference between the perceptions of construction professionals on the most significant green building features that enhance the value of a building.	FA, reliability test, and ANOVA
The perceptions about the current practices for valuing green building projects do not differ among construction participants.	ANOVA

3.6.2.3 One-way analysis of variance (ANOVA)

ANOVA is a commonly used method to evaluate the differences in mean between two groups of data, and more than two groups of data, respectively (Elliot & Woodward, 2007; Fellows & Liu, 2008). Therefore, the population standard deviation was estimated based on the sample standard deviation, with the levels of significance for the ANOVA at 0.05.

3.6.2.4 Validity and reliability of the data

Heale and Twycross (2015:66) define *validity* as the extent to which a concept is accurately measured in a quantitative study. The second measure of quality in a quantitative study is *reliability*, or the accuracy of an instrument; that is, the extent to which a research instrument consistently generates the same results if applied in the same situation on repeated occasions. Perakyla (2004) states that enhancing objectivity, a concrete activity, involves efforts to guarantee the accuracy and inclusiveness of recordings that the research is based on, along with the efforts to test the reliability of the analytic claims made about those recordings. Validity and reliability take different forms depending on the nature of the research problem, the general methodology that will be used to address the problem, and the nature of the data collected. Validity and reliability are two most important fundamental features in the evaluation of any measurement instrument or tool for a good research (Mohajan, 2018:1).

3.6.2.5 Reliability

According to Mohajan (2018:1), *reliability* is the degree of confidence or certainty that a researcher can have in the data obtained from the use of an instrument; that is, the degree to which any measuring tool controls for random error. Furthermore, Mohajan (2017:10) refers to *reliability* as a measurement that supplies consistent results with equal values. It measures consistency, precision, repeatability and trustworthiness of a research identifying the extent of error free research. By doing so, it insures consistent measurement across the various items in the instruments. Leedy and Ormrod (2010) define *reliability* as the consistency with which a measuring instrument yields a certain result when the entity being measured has not changed. Gomm (2008) supports the above statement by stating that internal consistency may be tested by using statistical tests, such as Kuder-Richardson formula 20(KR-20) or Cronbach's co-efficient alpha, by split-half techniques or by factor analysis. In this study, an internal reliability test was done on Likert-scaled type questions using Cronbach's co-efficient alpha.

Alpha, developed by Lee Cronbach to measure the internal consistency of a test or scale, is expressed as a number between 0 and 1 (Maree & Pietersen, 2007:216). The internal consistency described the extent to which all the items in a test measure the same concept or construct. Hence, it is a necessary but not sufficient condition for measuring homogeneity or unidimensionality in a sample of test items. Fundamentally, the concept of reliability assumes that unidimensionality exists in a sample of test items. However, if this assumption is violated, it will cause an underestimation of reliability. It is documented that a multidimensional test does not necessarily have a lower alpha than a unidimensional test. Thus, it is understood that alpha cannot simply be interpreted as an index for the internal consistency of a test (Tavakol & Dennick, 2011:53).

3.6.2.6 Validity

According to Leedy and Ormrod (2010), *validity* of a measuring instrument is the extent to which the instrument measures what it is supposed to measure. Similarly, research validity involves 'what an instrument measures', and 'how well it does it'. It is the degree to which the results are truthful (Mohajan 2017:14). Furthermore, Denscombe (2014:367) adds that validity of a research can be addressed by the use of respondent validation, grounded data and triangulation.

3.7 Chapter summary

This chapter represents a synopsis of the research methodology adopted in this study. The research methodology covers the study scope, data collection and data analysis. Methods of collecting both primary and secondary data were outlined, along with relevant literature reviews and questionnaire surveys. As part of the discussions, the quantitative method was discussed and considered for adoption in this chapter, delineating its advantages and disadvantages. In addition, the population and sampling methods were appropriately reviewed, together with the sampling technique. The classification of the data collected, whether as primary and secondary, was thoroughly examined, including other significant parts of this chapter such as questionnaire design, survey administration and activity. Discussions on descriptive statistics including the mean, median, mode, standard deviation and inferential statistics such as ANOVA, factor analysis and principal component analysis are evident as well. The chapter concluded by discussing study validity and reliability, assessing their respective importance to this study. The subsequent chapter discusses the findings attained through the appropriate application of the research methodology as discussed in this chapter.

CHAPTER FOUR

Data analysis and presentation

4.1 Introduction

This chapter presents the analysis of data collected with the use of questionnaires distributed to construction professionals via email and hand-delivery. The chapter entails testing of research instruments for reliability purposes. As part of the discussion in this chapter, the background detail of the survey participants and their respective qualification levels, from occupation to experience with the adoption and application of a green building concept within the construction industry were adequately presented. Furthermore, the chapter presents the interpretation and discussion of findings on the benefits of green building, green building features, and the influence of a green building concept on the value of a building in terms of cost, quality and usage. Finally, this chapter concludes by analysing the underlying tangible and intangible benefits of a green building concept, along with the green building features that influence the value of a building, determined through factor analysis.

4.2 Background information

This presents a brief overview of the background information of the respondents, including the highest qualification of the respondents, their occupations, and their experience in the construction industry with adoption and application of a green building concept.

4.2.1 Qualification of respondents

As displayed in Table 0.1, it is observed that 32.7% of the respondents are Matric holders, 28% hold a *National diploma*, 27.1% hold a *Btech/Bsc* degree, 10.3% hold a *BSc* Honour degree, and 1.9% hold an *MSc/Mtech* degree. However, it is important to note that a total percentage of 67.3% of the respondents hold tertiary qualifications.

Table 0.1: Qualification of respondents

Highest qualification	Frequency	Percentage (%)
MSc/MTech	2	1.9
BSc (Hon)	11	10.3
BTech/BSc	29	27.1
N Diploma	30	28.0
Matric Certificate	35	32.7
Total	**107**	**100.0**

4.2.2 Occupation of respondents

As part of the findings gathered, as displayed in Table 0.2, it is clear that 19.6% of the respondents are green building/sustainability specialists, 18.7% are engineers, 12.1% are estate surveyors and managers, while 11.2% are property managers. In addition, 8.4% of the respondents are architects, 6.5% are town planners, 5.6% are foremen, 5.6% are building technicians, 5.6% are quantity surveyors, 4.7% are project managers while a nominal 1.9% are site managers. It is important to note that the respondents who participated in the survey represent a broad spectrum of various professions within the built environment.

Table 0.2: Occupation of respondents

Occupation	Frequency	Percentage
Site manager	2	1.9
Project manager	5	4.7
Quantity surveyor	6	5.6
Building technician	6	5.6
Foreman	6	5.6
Town planner	7	6.5
Architect	9	8.4
Property manager	12	11.2
Estate surveyor and manager	13	12.1
Engineer	20	18.7
Green building/sustainability specialist	21	19.6
Total	**107**	**100.0**

4.2.3 Work experience

Results tabularised in Table 3.3 below demonstrated the duration of experience of the respondents with their current employer. Observations indicate that 50.5% of the respondents have fewer than five years of work experience with their current employer, followed by a determination 44.9% and 4.7% for the respondents who have five to 10 years and more than 10 years, respectively, with their current employer. From the above illustration, it is deduced that a total estimate of 49.6% of the respondents have extensive experience in their current position, from five years or higher on the adoption and application of green building concept. Therefore, this large, experienced percentage will contribute immensely to the gathering and attaining of adequate findings pertinent to the purpose of the study.

Table 0.3: Tabularised illustration of respondent work experience

Duration of experience with current employer	Frequency	Percentage
More than 10 years	5	4.7
5-10 years	48	44.9
Less than 5 years	54	50.5
Total	**107**	**100.0**

4.2.4 Experience in construction

From the result shown in Table 0.4, 60.7% of the respondents had less than five years of experience in the construction industry, followed by 32.7% respondents with five to 10 years of experience in the construction industry, while the remaining 6.5% of the respondents had over 10 years of experience in the construction industry.

Table 0.4: Tabularised illustration of respondent experience level in construction

Duration of practice	Frequency	Percentage
More than 10 years	7	6.5
5-10 years	35	32.7
Less than 5 years	65	60.7
Total	**107**	**100.0**

4.2.5 Awareness and adoption of a green building concept

The findings attained from the analysis of the adoption and awareness of a green building concept, as displayed in Table 0.5, demonstrate that 9.3% of the respondents are 'unsure' of their awareness and adoption of the concept of a green building. Alternatively, 23.4% of the respondents claimed that they are not aware; while a large percentage (67.3%) of respondents claimed that they are aware and have already adopted a green building concept. This suggests that more than two thirds of the respondents (67.3%) are aware of and have adopted the concept of a green building, and a similar affirmation is applied to their respective organisations.

Table 0.5: Awareness and adoption of a green building concept

Awareness and adoption of a green concept	Frequency	Percentage
No	25	23.4
Yes	72	67.3
Unsure	10	9.3
Total	**107**	**100.0**

4.2.6 Application of a green building concept

The findings obtained from the analysis of the application of a green building concept, as tabulated in Table 0.6, illustrate that 25.3% of the respondents work on a green building projects 'very often', followed by 24.2% respondents who 'often' work on a green building projects, with a remaining percentage of 20.9% of respondents who prefer to respond as 'neutral' to the question asked. Although an equal estimate of 12.1% respondents claim that they are 'not so often' or 'not often' working on a green building projects, while a small percentage (5.1%) of respondents claim they are 'unsure' of the concept. This therefore means that 49.5% of the respondents are regularly implementing and working on green building projects.

Table 0.6: Application of a green building concept

Application of green building concept	Frequency	Percentage
Very often	23	25.3
Often	22	24.2
Neutral	19	20.9
Not so often	11	12.1
Not often	11	12.1
Unsure	5	5.1
Total	**91**	**100.0**

4.3 Interpretation and definition of the scales

The interpretation and definition of the scales applied in determining the exact positions of the affirmative responses to the questions to respondents are tabulated in Table 0.7. The scale was dimensioned from 'unsure' to other metrics, ranging from 'minor' to 'major', that is, a Likert scale ranging from 1 to 5. For instance, observations indicate that highest *mean score* range of $> 4.20 \leq 5.00$ represents respondent responses between 'near major extent' to 'major/major extent' for question 7, although it depends on the choice of options selected by the respondents. This explains the degree to which respondent opinions differed about the effect of tangible and intangible benefits of green building on the value of a building in South Africa. Similar interpretation is applied to other questions from 8 to 9, and 10 to 12.

Table 0.7: Definition of the scales

Question no.	Mean score range	Meaning
7.1 and 7.2	> 4.20 ≤ 5.00	Between near major extent to major/major extent
	> 3.40 ≤ 4.20	Between some extent to a near major/near major extent
	> 2.60 ≤ 3.40	Between near minor extent to some extent/some extent
	> 1.80 ≤ 2.60	Between minor to a near minor/near minor extent
	≥ 1.00 ≤ 1.80	Between minor to near minor extent
8 and 9	> 4.20 ≤ 5.00	Between important to most important/most important
	> 3.40 ≤ 4.20	Between neutral to important/important
	> 2.60 ≤ 3.40	Between not so important to neutral/neutral
	> 1.80 ≤ 2.60	Between least important to not so important/not so important
	≥ 1.00 ≤ 1.80	Between least important to not so important
10 and 12	> 4.20 ≤ 5.00	Between effective to very effective/very effective
	> 3.40 ≤ 4.20	Between neutral to effective/effective
	> 2.60 ≤ 3.40	Between not so effective to neutral/neutral
	> 1.80 ≤ 2.60	Between not effective to not so effective/not so effective
	≥ 1.00 ≤ 1.80	Between not effective to not so effective

4.4 Benefits of a green building

This section discusses the findings derived from the analysis of benefits associated with a green building. The benefits were classified into tangible and intangible benefits, outlining specifically the material/physical benefits and the impalpable/invisible benefits.

4.4.1 Tangible benefits that influence the value of a building

The findings obtained from the analysis of the tangible benefits that influence the value of a building, as displayed in Table 0.8, demonstrate the extent to which this form of benefit affects the value of a building on a 5-point Likert scale ranging from 1 to 5 with a mid-point value of 3.0. From the table, observations show that all the mean values (MV) for the factors are above 3.0, indicating that these tangible benefits associated with a green building contribute more of a ‘major extent’ than a ‘minor extent’ in influencing the value of a building.

Table 0.8: Tangible benefits of green building that influence the value of a building

Tangible benefits	Unsure	Minor.......................Major					SD	MV	Rank
		1	2	3	4	5			
It reduces energy consumption	2.8	2.8	7.5	20.6	24.3	42.1	1.12	3.98	1
It preserves natural resources	1.9	2.8	9.3	18.7	31.8	35.5	1.09	3.90	2
It reduces water consumption	1.9	5.6	6.5	16.8	34.6	34.6	1.16	3.87	3
It lowers operation cost	6.5	2.8	13.1	19.6	27.1	30.8	1.15	3.75	4
It promotes waste management	5.6	6.5	11.2	20.6	21.5	34.6	1.27	3.70	5
It provides for flexible design options due to varying technologies	0.9	4.7	14.0	14.0	29.0	37.4	1.05	3.42	6

It allows for central control of building activities (e.g. the use of central biometric system)	3.7	7.5	8.4	14.0	30.8	35.5	1.09	3.42	7
It reduces dilapidation in buildings (e.g. the use of glaze glass, monolithic walls)	4.7	12.1	18.7	31.8	32.7	0.0	0.95	3.39	8
Tax payment is reduced	9.3	2.8	13.1	20.6	26.2	28.0	1.07	3.29	9
It reduces maintenance cost	28	8.4	15.0	16.8	19.6	37.4	1.17	3.22	10

It is observed that a green building contributes more to the *reduction of energy consumption*, as the variable is ranked first in the table, with a MV of 3.98, followed by *preserves natural resources* with a MV of 3.90, and *reduces water consumption,* with a MV of 3.87. From the pattern of the MVs, as shown in the table, it is clear that respondents' perceptions about the first seven tangible benefits in a green building are optimistic. This is attributed to a small variation between MVs which fall within the mean score range of > 3.40 ≤ 4.20, and determined to be 'between some extents to a near major/near major extent'. The illustration signifies that the first seven benefits are nearer to 'major extent' ahead of other tangible benefits of green building on the value of a building in the South African context.

In addition, the remaining three benefits fall within the mean score range of > 2.60 ≤ 3.40, exhibiting the significance of these benefits in a green building initiative in South Africa. Despite these benefits being determined as 'between near minor extent to some extent/some extent', a green building still contributes to *reduces building dilapidation, reduces tax payment,* and *reduces maintenance cost*.

4.4.2 Intangible benefits that influence the value of a building

The findings derived from the analysis of intangible benefits of a green building influence on the value of a building are tabularised in

Table 0.9. The analysis was carried out with the similar approach used in subsection 4.4.1 for the tangible benefits. From the table, observations show that all the MVs for the factors are above 3.0, indicating that the intangible benefits associated with green building contribute more of a 'major extent' than a 'minor extent' in influencing the value of a building.

Table 0.9: Intangible benefits of green building influencing the value of a building

Intangible benefits	Unsure	Minor………………….Major					SD	MV	Rank
		1	2	3	4	5			
Reduces negative environmental impact	1.9	0.9	5.6	22.4	34.6	34.6	0.93	4.03	1
Improves company brand equity and goodwill	2.8	0.9	6.5	23.4	30.8	35.5	0.96	3.91	2
Increases property value	5.6	4.7	22.4	23.4	43.9	0.0	0.83	3.91	2
Improves indoor air quality	1.9	1.9	6.5	20.6	20.6	48.6	0.91	3.81	4
Improves health of building occupants	1.9	4.7	23.4	30.8	32.7	0.0	1.10	3.80	5
Reduces liability risk	0.9	0.9	12.1	21.5	25.2	39.3	0.98	3.69	6
Increases user productivity	1.9	1.9	12.1	21.5	29.0	33.6	1.09	3.65	7
It is technologically friendly and adaptive	1.9	2.8	10.3	21.5	29.0	34.6	1.04	3.57	8
Provides better security means for users (e.g. central lock and alarm system)	2.8	0.9	18.7	24.3	26.2	27.1	1.09	3.57	9
It has a good hedge against inflation due to constantly changing technology	1.9	1.9	13.1	21.5	29.0	32.7	1.02	3.30	10

It is observed that a green building contributes more to *reducing environmental impact,* as this variable is ranked highest in the table, with an MV of 4.03, followed by green building *improves company brand equity and goodwill* and *increases property value*, with equal MV values of 3.91. From the pattern of the MVs, as displayed in the table, it is deduced that respondent perceptions about the first nine intangible benefits in a green building are encouraging. This is due to small variation between the MVs falling within the mean score range of > 3.40 ≤ 4.20, determined as 'between some extent to a near major/near major extent'. This demonstrates that the first nine benefits are getting nearer to 'major extent' ahead of other intangible benefits of a green building on the value of a building in the South African construction industry. Moreover, the degree of concurrence for the remaining factor, *green building has a hedge against inflation due to constantly changing technology,* is between 'near minor extent to some extent/some extent' since the MV is > 2.60 ≤ 3.40.

4.5 Green building features and impact on the value of a building

This section examines the features of green building and how these influence the value of a building. The respondents' perceptions were measured with the use of Likert scale, dimensioned from 1 to 5, that is, ranging from most important to the least important features. The findings derived from analysis of green building features influencing the value of a building, displayed in Table 0.10, indicate that 24 out of the 26 (92%) factors yielded MVs above 3.0, suggesting that these 24 features are more significant in influencing the value of a building than the last two features with lower MVs.

From the table, it is noted that *kitchen and WC water efficient fittings* is ranked highest, with an MV of 3.91, followed by *megawatt photovoltaic solar plant* with an MV of 3.79, and *water metering for monitoring and leak detection* with an MV of 3.74. Considering the MVs, it is clear that these features have a significant influence on the value of a green building. In addition, from the distribution shape of the MVs across the first 13 features, it is evident that their impact on the value of a building falls 'between neutral to important/important'.

Table 0.10: Features of a green building

Features	Unsure	Least important..................Most important					SD	MV	Rank
		1	2	3	4	5			
Kitchen and WC water efficient fittings (e.g. censored taps, grey water collector)	1.9	2.8	29.9	32.7	32.7	0.0	0.87	3.91	1
Megawatt photovoltaic solar plant	6.5	0.9	7.5	21.5	23.4	40.2	0.92	3.79	2
Water metering for monitoring and leak detection	3.7	3.7	3.7	25.2	31.8	31.8	1.02	3.74	3
Photovoltaic solar panel system on building roof	2.8	5.6	12.1	20.6	29.0	29.9	1.20	3.66	4
Economy cycle water recycling systems (e.g. rain water and grey water harvesting)	5.6	8.4	18.7	32.7	34.6	0.0	0.90	3.65	5
Electrical sub-metering used for individual billing purposes	6.5	10.3	17.8	30.8	34.6	0.0	0.92	3.64	6
High performance building façade and skylight	1.9	8.4	17.8	35.5	36.4	0.0	0.88	3.64	7
Borehole water and reverse osmosis plant cyclist and shower facilities	3.7	3.7	7.5	16.8	26.2	42.1	0.99	3.63	8
Heating and cooling provided by a 3-pipe variable refrigerant flow (VRF) system	4.7	1.9	11.2	18.7	29.9	33.6	1.00	3.59	9
Recycled glass and steel	3.7	12.1	12.1	31.8	40.2	0.0	0.87	3.54	10
Use of roof light (e.g. tear drops)	4.7	5.6	7.5	7.5	19.6	55.1	1.00	3.52	11

Use of inverters, (a multi split air conditioner e.g. VRV III) to enable individual zone control	7.5	4.7	10.3	13.1	23.4	41.1	1.03	3.42	12
Vegetation efficient drip irrigation system	3.7	3.7	10.3	13.1	30.8	38.3	0.99	3.41	13
Timber flooring from a certified plantation	4.7	3.7	12.1	14.0	31.8	33.6	1.02	3.38	14
Use of daylight censored high performance chilled water	10.3	0.9	6.5	17.8	26.2	38.3	0.92	3.35	15
Atrium roof lights	3.7	3.7	6.5	16.8	27.1	42.1	0.97	3.32	16
Renewable materials like bamboo and rubber	1.9	3.7	7.5	14.0	36.4	36.4	0.94	3.30	17
Biometric reader system (BRM)	9.3	2.8	10.3	17.8	26.2	33.6	1.00	3.26	18
Use of light shelves	1.9	2.8	4.7	19.6	32.7	38.3	0.92	3.23	19
Black water recycling system	9.3	2.8	13.1	14.0	22.4	38.3	1.05	3.13	20
Triple-glazed windows	6.5	6.5	8.4	12.1	19.6	46.7	0.99	3.12	21
Carpets made from 100% recycled material	3.7	4.7	8.4	25.2	28.0	29.9	1.07	3.10	22
Electric car and bicycle charging points	7.5	3.7	11.2	18.7	26.2	32.7	1.07	3.08	23
Recycled cork panels and flooring	10.3	3.7	7.5	15.0	23.4	40.2	0.97	3.01	24
Wind energy (e.g. wind turbines and wind power plant)	2.8	9.3	12.1	22.4	25.2	28.0	1.20	2.97	25
Use of sunglasses	7.5	10.3	15.0	15.9	17.8	33.6	1.21	2.92	26

Mean score range of > 3.40 ≤ 4.20. Similarly, the distribution shape of the MVs across the other 13 features placed their impact on the value of a building 'between not so important to neutral/neutral', with a mean score range > 2.60 ≤ 3.40. The features include *timber flooring from a certified plantation, the use of daylight censored high performance chilled water, atrium roof lights, renewable materials like bamboo and rubber, biometric reader system (BRM), the use of light shelves, black water recycling system triple-glazed windows, carpets made from 100% recycled material, electric car and bicycle charging points, recycled cork panels and flooring, wind energy,* and *the use of sunglasses*.

4.6 Potential impact of cost, quality and usage on the value of a green building

Having determined the importance of green building features, it is necessary to understand that there are no restrictions, eagerly leading to knowledge of which other aspect(s) have the greatest potential impact on the value of a green building. In that case, the findings derived from the analysis of the potential impact of cost, quality and usage on the value of a green building are discussed in this section. Table 0.11 displays the statistical deductions regarding the various aspects of the value relative to green building, presented to demonstrate the distribution of data or scores across the three determinants of the value of a green building in South Africa.

In the process of attaining these results, a 5-point Likert scale measured the impact of the three determinants, dimensioned from 1 to 5, that is, ranging from most important to least important founded on the distribution pattern of the MVs from the highest value to the lowest value. The positioning of the relevant variables, categorised under the three determinants *(cost, quality and usage),* ranked either above or below the midpoint score of 3.00. As However these factors may significantly influence the value of a building in the South African built environment, the values are tabularised in three categories (Table 0.11): the first section represents the analysis results of the impact of *cost* on the value of a building; the second section represents the results derived from the analysis of the impact of the *quality* on the value of a building; the third section presents results obtained from the analysis of the impact of *usage* on the value of a building.

Table 0.11: Potential impact of cost, quality and usage on the value of a green building

Aspects cost	Unsure	least important ……most important					SD	MV	Rank
		1	2	3	4	5			
Cost									
It reduces the life cycle cost of a building	3.7	3.7	6.5	17.8	25.2	43.0	1.13	4.01	1
It reduces utilities cost	2.8	5.6	7.5	12.1	35.5	35.5	1.17	3.93	2
It reduces operating cost	2.8	2.8	9.3	16.8	33.6	34.6	1.08	3.89	3
It reduces maintenance cost	1.9	1.9	8.4	22.4	25.2	40.2	0.98	3.80	4
It increases revenue	3.7	0.9	10.3	24.3	27.1	33.6	1.01	3.66	5
It reduces liability risk	2.8	7.5	7.5	21.5	24.3	36.4	1.17	3.64	6
It lowers service charge	8.4	2.8	13.1	17.8	21.5	36.4	1.02	3.63	7
It lowers production cost	9.3	2.8	10.3	17.8	22.4	37.4	1.05	3.58	8
It reduces management cost	5.6	4.7	15.0	17.8	28.0	29.0	1.00	3.44	9
It reduces occupancy premium	8.4	3.7	10.3	12.1	26.2	39.3	1.12	3.42	10
It reduces tax payment	10.3	4.7	16.8	20.6	23.4	24.3	1.17	3.31	11
Quality									
It improves the quality of natural lighting	3.7	2.8	26.2	29.0	38.3	0.0	0.91	4.04	1
Improves indoor air quality	4.7	0.9	7.5	15.9	34.6	36.4	0.98	4.03	2
It reduces negative environmental impact	1.9	1.9	12.1	17.8	30.8	35.5	1.07	3.83	3

It improves company brand	1.9	1.9	12.1	20.6	26.2	37.4	1.05	3.75	4
It preserves natural resources	1.9	1.9	5.6	24.3	32.7	33.6	0.96	3.74	5
It promotes company goodwill	1.9	1.9	11.2	15.9	19.6	49.5	0.95	3.68	6
Usage									
It reduces water consumption	2.8	0.9	7.5	24.3	31.8	32.7	0.99	3.89	1
Energy usage is more efficient	1.9	3.7	6.5	24.3	29.0	34.6	1.11	3.81	2
It promotes waste management	1.9	1.9	13.1	26.2	27.1	29.9	1.07	3.67	3
It provides access to outdoor natural views	1.9	0.9	13.1	26.2	27.1	30.8	1.05	3.66	4
Improved health of building occupants	3.7	2.8	8.4	15.0	24.3	45.8	0.95	3.64	5
It minimises/reduces risk	1.9	3.7	19.6	21.5	26.2	27.1	1.20	3.54	6
It increases user productivity	3.7	17.8	25.2	35.5	39	0.0	1.07	3.52	7
It reduces noise as materials such as glaze glasses and mass concrete walls are used	1.9	11.2	20.6	30.8	35.5	0.0	0.94	3.33	8
It reduces drafts (A device that regulates the flow or circulation of air)	4.7	4.7	10.3	20.6	26.2	33.6	1.07	3.25	9
It minimises floor-to-ceiling temperature stratification	2.8	8.4	11.2	15.9	29.0	32.7	1.13	3.08	10

The *cost* section of the table reveals that an MV of 4.01 demonstrates that *reduction in life cycle cost of a building* is ranked highest and therefore is highly vital in influencing the value of a green building. This result is followed by *reduction in utilities cost* with an MV of 3.93, and *reduction in operating cost* with a MV of 3.89. The MV distribution shape across the first 10 factors, in terms of *cost,* demonstrated small variations falling within the mean score range of > 3.40 ≤ 4.20, determined as 'between neutral to important/important'. In addition, the last variable *(reduction in tax payment)* of the 11 factors categorised under the *cost* section yielded an MV of 3.31 placing it within a mean score range of > 2.60 ≤ 3.40, determined as 'between not so important to neutral/neutral'.

Quality, the second of the three determinants, has tabularised factors that define its potential impact on the value of a green building. The findings attained demonstrate a similar distribution structure of the MVs to that of the first determinant *(cost)* observed. However, in the *quality* section of the table, observations indicate that *improvement in quality of natural lighting* is ranked highest, with an MV of 4.04, followed by the *improvement in indoor air quality* with a close MV of 4.03, and *reduction in negative environmental impact* with an MV of 3.83.

The impact of the six factors on the value of a building, as measured with the use of Likert scale, fall within a mean score range of > 3.40 ≤ 4.20, determined as 'between neutral to important/important'.

In view of *usage,* similar results are obtained, with all MVs above the midpoint of 3.0, signifying that the use of green building, in respect to *usage,* has significant influence on the value of a building. The findings observed show that the MV distribution shape is similar to the first two determinants, wherein *reduction in water consumption* is ranked highest with an MV of 3.89, followed by the *efficiency increase of energy usage* with an MV of 3.81 and *promoting waste management* with an MV of 3.67. Hence, the impact of the first seven factors on the value of a building, as measured with a Likert scale, fall within a mean score range of > 3.40 ≤ 4.20, determined as 'between neutral to important/important'; the impact of the last three factors on the value of a building fall within a mean score range of > 2.60 ≤ 3.40, determined as 'between not so important to neutral/neutral', with factors including *reduction in noise, reduction in drafts,* and *minimising floor-to-ceiling temperature stratification.*

4.7 Current technologies adopted in a green building

The results attained from the statistical analysis for the current technologies adopted in green building are tabulated in Table 0.12. In the process, a Likert scale was used, dimensioned from 1 to 5, interpreted as 'not effective' to 'very effective' with a midpoint value of 3.00 to enable appropriate grouping of the MVs. From the table, observations reveal that only four out of eight (50%) of the current technologies adopted in a green building have MVs above the midpoint of 3.00, suggesting that current technologies with MVs above the midpoint value considerably influence the value of a building. Numerically, it is deduced that *solar power* is ranked highest, with an MV of 4.14, followed by *municipal solid waste (MSW)* with an MV of 3.70, and *land fill gas (LFG)* with an MV of 3.29.

Table 0.12: Current technologies adopted in a green building

Technology	Unsure	Not effective.........Very effective					SD	MV	Rank
		1	2	3	4	5			
Solar power	6.5	1.9	5.6	16.8	22.4	46.7	1.05	4.14	1
Municipal solid waste (MSW)	8.4	4.7	8.4	19.6	23.4	35.5	1.11	3.70	2
Land fill gas (LFG)	5.6	7.5	13.1	13.1	29.0	31.8	1.12	3.29	3
Hydropower	3.7	7.5	9.3	20.6	25.2	33.6	1.13	3.10	4
Biomass	6.5	6.5	8.4	15.0	19.6	43.9	1.01	2.99	5
Geothermal methods	9.3	2.8	4.7	17.8	22.4	43.0	0.88	2.91	6

Ocean (tidal) energy	3.7	1.9	15.0	19.6	24.3	35.5	1.11	2.73	7
Wind (aeolic)	3.7	4.7	14.0	15.0	25.2	37.4	1.16	2.68	8

The distribution shape of the MVs across the eight technologies, as displayed in Table 4.12, indicates that some technology impact levels fall within the mean score range of > 3.40 ≤ 4.20, while other technology impact levels fall below this particular mean score range. According to this illustration, technologies such as *solar power* and *MSW* have their impact levels within the mean score range of > 3.40 ≤ 4.20, determined to be 'between neutral to effective/effective'. Contrarily, another six technology impact levels in green building fall within the mean score range of > 2.60 ≤ 3.40, determined to be 'between not so effective to neutral/neutral': *LFG, hydro power, biomass, geothermal methods, ocean (tidal) energy,* and *wind (aeolic).* Overall interpretation of these findings reveals that *solar power* is the most frequently adopted green technology among the others.

4.8 Challenges encountered implementing a green concept

In the process of implementing a green concept, there are several challenges encountered. In determining the likely challenges encountered in the implementation process of a green concept, some options were dimensioned to measure the respondent opinions. These options, formulated as 'unsure', 'yes', and 'no', determine the potential existence of challenges during the implementation of a green concepts.

Table 0.13: Challenges encountered implementing a green concept

Challenges	Frequency	Percentage
Unsure	38	41.8
Yes	29	31.9
No	24	26.4
Total	**91**	**100.0**

In accordance with the results in

Table 0.13, it is confirmed that large number of respondents, 41.8%, disclosed that they are 'unsure' of any possible existence of challenges during the implementation of a green building concept. Conversely, 31.9% of the respondents affirmed that challenges are encountered in the process of implementing a green building concept, while the smallest percentage, 26.4% of the respondents, claimed that they have never experienced any potential challenges during the implementation of a green building concept.

To substantiate this illustration, the respondents who gave affirmative responses were persuaded to specify the challenges they may have encountered in the process, as identified below:

- Uncertainty in attaining standards
- SABS standards difficult to attain
- High cost of attaining green building rating standard
- Difficulties in getting the right specialists.
- High cost maintenance due to specialists' service demands in technology
- Use of low-quality materials in developing green buildings
- High comparative cost between green buildings and traditional method, only paying off in long term
- Securing contractors and maintaining site regulations
- High standard due to GBC requirements
- High cost of labour due to required specialists
- High cost of building materials, imported materials mostly
- Delays in construction material registering, time consuming.
- High capital intensive
- Difficulty in compiling supplier names as registered by the green building council of South Africa

4.9 Methods used in determining the value of a green building

The assessment results of the valuation methods used in determining the value of a green building are presented in Table 0.14. The process was measured with the use of a Likert scale and dimensioned from 1 to 5, represented as 'not effective' to 'very effective' with a midpoint value of 3.00 to facilitate the grouping of MVs. The table details disclose that five out of seven valuation methods have MVs above the midpoint of 3.00, illustrating the importance of using these methods in determining the value of a building.

Observations denote that *building sustainability assessment method (BSA)* is the top ranked valuation method with an MV of 3.79, followed by *comparative market analysis (CMA)* with an MV of 3.71, and *cost method* with an MV of 3.44. In accordance with the results, the first four valuation methods demonstrate high importance in determining the value of a green building, because their MVs fall within the mean score range of > 3.40 ≤ 4.20, which is determined to be 'between neutral to effective/effective'. In addition, the MVs of the last three methods fall within the mean score range of > 2.60 ≤ 3.40, determined to be 'between not so effective to neutral/neutral'. The methods include *income method, direct capitalisation method, and discounted cash flow analysis.*

Table 0.14: Methods used for determining the value of a green building

Valuation methods	1	2	3	4	5	SD	MV	Rank
Building sustainability assessment (BSA) method	3.7	6.5	25.2	29.0	34.6	1.06	3.79	**1**
Comparative market analysis (CMA), a computer-based method	5.6	7.5	27.1	29.0	29.9	1.15	3.71	2
Cost method (e.g. cost of land, cost of construction)	5.6	8.4	16.8	32.7	35.5	1.11	3.44	3
Sales comparison method (market approach)	3.7	13.1	18.7	22.4	41.1	1.06	3.42	4
Income method	14.0	15.9	16.8	18.7	32.7	1.27	3.03	5
Direct capitalisation method	4.7	9.3	24.3	27.1	32.7	1.04	2.88	6
Discounted cash flow analysis	2.8	9.3	17.8	27.1	41.1	0.95	2.77	7

In the process of implementing a green concept, several valuation techniques were considered by professionals to initiate this procedure. With the objective of determining these techniques, options were dimensioned to guide the opinions of the respondents. These options are formulated as ‘unsure’, ‘yes’, and ‘no’, to determine the valuation techniques.

Table 0.15: Specific techniques adopted by professionals

Specific valuation techniques	Frequency	Percentage (%)
Unsure	21	24.7
Yes	5	5.9
No	59	69.4
Total	**85**	**100.0**

Observably, 24.7% of the respondents disclosed that they are ‘unsure’ of any specific techniques, and a sizeable percentage (69.4%) of respondents do not know any specific technique, while a nominal percentage (5.9%) of the respondents affirmed that some specific valuation techniques were adopted, as outlined below:

- cost saving efficient method;
- building and material costing;
- use of eco-protect slabs between different floors to reduce heat loss on copper pipe conduits; and
- cost saving levels to justify the value of the building.

4.10 Identifying the influence of green building features on the value of a building

This subsection presents the analysis results for determining the influence of green building features on the value of a building. In the process, 26 variables were evaluated as features with positive or negative impact on the value of a green building. The analysis process was initiated through the application of PCA analysis tool on the SPSS version 25.

The application of PCA uncovered seven components under this category with eigenvalues greater than one. These components represent 70.42% of the total variance of the 26 features criteria, as displayed in Table 3.16 below. The values displayed in this table, graphically presented in the scree plot in Figure 3.1 below, indicate a clear break after the seventh component. In addition, the Promax rotation was adopted to aid the interpretation of the seven components, with results showing that the first-seven components have a number of loadings above 0.3 on pattern matrix (Table 3.17).

Table 0.16: Total variance attained for the features of a green building

Component	Total	Initial Eigenvalues		Total	Extraction Sums of Squared Loadings		Rotation Sums of Squared Loadings Total
		% of Variance	Cumulative %		% of Variance	Cumulative %	
1	7.531	28.965	28.965	7.531	28.965	28.965	
2	3.977	15.295	44.261	3.977	15.295	44.261	6.061
3	1.933	7.436	51.696	1.933	7.436	51.696	3.602
4	1.455	5.596	57.292	1.455	5.596	57.292	3.598
5	1.390	5.347	62.639	1.390	5.347	62.639	4.129
6	1.021	3.927	66.566	1.021	3.927	66.566	4.117
7	1.002	3.854	70.420	1.002	3.854	70.420	2.457
8	0.925	3.556	73.976				2.662
9	0.848	3.263	77.239				
10	0.770	2.962	80.202				
11	0.684	2.632	82.834				
12	0.635	2.441	85.274				
13	0.569	2.188	87.462				
14	0.477	1.835	89.297				
15	0.453	1.741	91.038				
16	0.357	1.372	92.410				
17	0.322	1.238	93.648				
18	0.276	1.062	94.710				
19	0.267	1.029	95.739				
20	0.233	0.895	96.634				
21	0.203	0.782	97.416				
22	0.190	0.729	98.145				
23	0.151	0.579	98.724				
24	0.138	0.529	99.253				
25	0.106	0.409	99.662				
26	0.088	0.338	100.000				

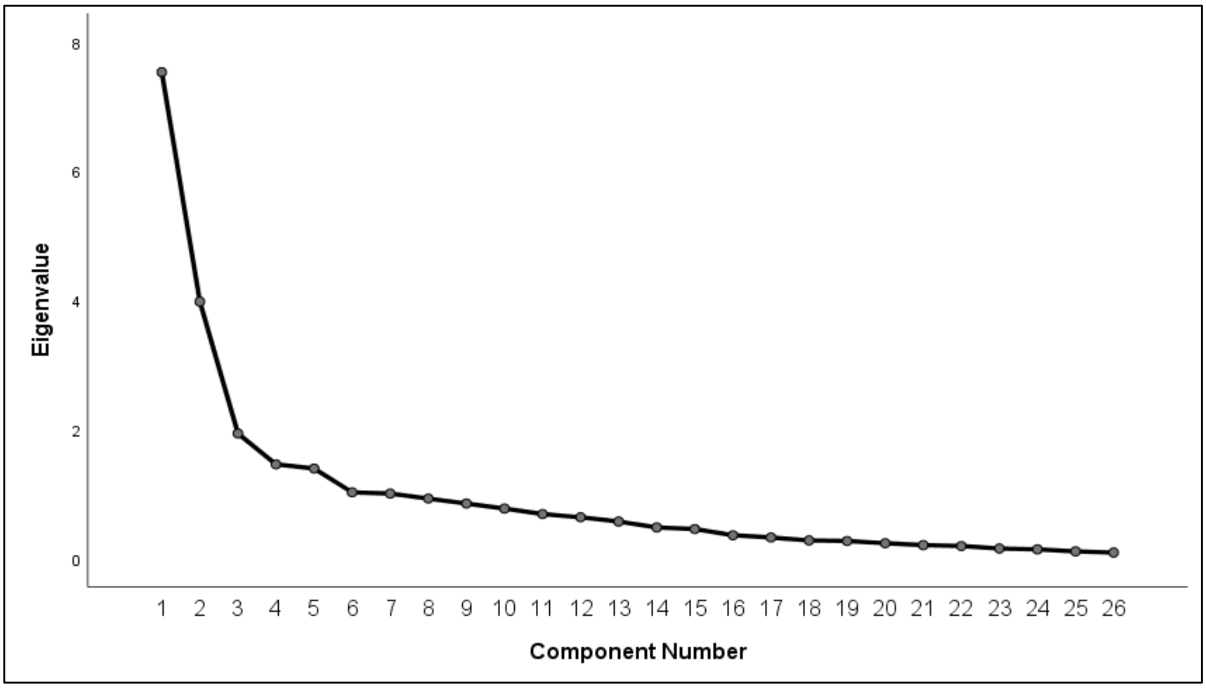

Figure 0.1: Catell's scree plot for features of green building

The interpretation of these findings, in reference to the loading pattern of the features of a green building, discloses that *eco-friendly materials and energy conservation feature* is the variable that converges at component 1, and others such as w*ater saving and renewable energy feature* converge at component 2, *safety feature* converges at component 3, *natural day light and control feature* converges at component 4, *sun shade and light feature* converges at component 5, *water management and flooring feature* converges at component 6, and *special utility feature* converges at component 7.

✦ Component 1: *Eco-friendly materials and energy conservation feature*

Under the first component, in terms of inter-correlation, seven features are related to the *eco-friendly materials and energy conservation feature,* such features as *recycled glass and steel, renewable materials like bamboo and rubber, high performance building façade and skylight, heating and cooling provided by a 3-pipe variable refrigerant flow (VRF) system, carpets made from 100% recycled material, wind energy,* and *electrical sub-metering used for individual billing purpose*.

✦ Component 2: *Water saving and renewable energy feature*

The second component includes four features: *economy cycle water recycling systems, kitchen and WC water efficient fittings, photovoltaic solar panel system on building roof,* and *megawatt photovoltaic solar plant*.

Table 0.17: Pattern matrix features of a green building

Variables	Components						
	1	2	3	4	5	6	7
Use of daylight censored high performance chilled water				0.472			
Economy cycle water recycling systems		0.673					
Kitchen and WC water efficient fittings		0.638					
Recycled glass and steel	0.756						
Renewable materials like bamboo and rubber	0.742						
High performance building façade and skylight	0.635						
Heating and cooling provided by a 3-pipe variable refrigerant flow (VRF) system	0.473						
Carpets made from 100% recycled material	0.856						
Wind energy (e.g. wind turbines and wind power plant)	0.444				0.394	0.320	
Photovoltaic solar panel system on building roof		0.898					
Megawatt photovoltaic solar plant		0.680		0.436			
Electrical sub-metering used for individual billing purposes	0.786						
Electric car and bicycle charging points							0.502
Biometric reader system (BRM)			0.498		0.348		
Black water recycling system						0.325	0.730
Water metering for monitoring and leak detection							0.409
Vegetation efficient drip irrigation system						0.808	
Borehole water and reverse osmosis plant cyclist and shower facilities						0.554	
Use of roof light (e.g. tear drops)				0.966			
Use of inverters, to enable individual zone control				0.661			

Recycled cork panels and flooring				0.331		0.363	
Use of sunglasses					0.862		
Triple-glazed windows			0.753				
Timber flooring from a certified plantation			0.797				
Atrium roof lights				0.383			
Use of light shelves					0.709		

✦ Component 3: *Safety features*

The third component consists of three features including *biometric reading system (BRM), triple-glazed windows* and *timber flooring from a certified plantation*

✦ Component 4: *Natural day light and control feature*

The fourth component is comprised of four features: as *use of daylight censored high performance chilled water, use of roof light, use of inverters to enable individual zone control,* and *atrium roof lights*.

✦ Component 5: S*unshade and light feature*

The fifth component is comprised of two features: *use of sunglasses* and *use of light shelve*.

✦ Component 6: *Water management and flooring feature*

The sixth component includes three features: *vegetation efficient drip irrigation system, borehole water and reverse osmosis plant cyclist and shower facilities* and *recycled cork panels and flooring*

✦ Component 7: S*pecial utility feature*

The seventh component constitutes three factors, including *electric car and bicycle charging point, black water recycling system,* and *water metering to enable-monitoring and leak detection*

4.11 Identifying the underlying tangible benefits of a green building concept on the value of a building

This subsection presents the analysis results of the determination of the underlying tangible benefits of a green building concept on the value of a building. In this case, 10 variables were determined to have a potential positive or negative influence on a green building. The analysis procedure applied is similar to the one used in subsection 4.10, where variable impacts were examined through the use of PCA analysis tool on the SPSS version 25.

The PCA analysis tool uncovered two components under this category with eigenvalues greater than one. These components represent 69.64% of the total variance of the 10 benefit criteria presented in Table 0.18 below. The values displayed in this table are represented in the graph (

Figure 0.2 below). The distribution of the values across the 10 variables, as displayed on the scree plot, indicated a clear break after the second component. Also, the Promax rotation was applied along in process to aid the interpretation of the two components. The results tabulated indicate that the first two components demonstrate a number of loadings above 0.3 on pattern matrix.

Table 0.18: Total variance attained for tangible benefits of a green building

Component	Total	Initial eigenvalues		Total	Extraction Sums of Squared Loadings		Rotation Sums of Squared Loadings
		% of Variance	Cumulative %		% of Variance	Cumulative %	Total
1	5.095	50.948	50.948	5.095	50.948	50.948	4.601
2	1.869	18.692	69.640	1.869	18.692	69.640	3.680
3	0.768	7.684	77.324				
4	0.507	5.074	82.398				
5	0.478	4.780	87.178				
6	0.393	3.934	91.112				
7	0.317	3.165	94.278				
8	0.267	2.668	96.945				
9	0.158	1.578	98.523				
10	0.148	1.477	100.000				

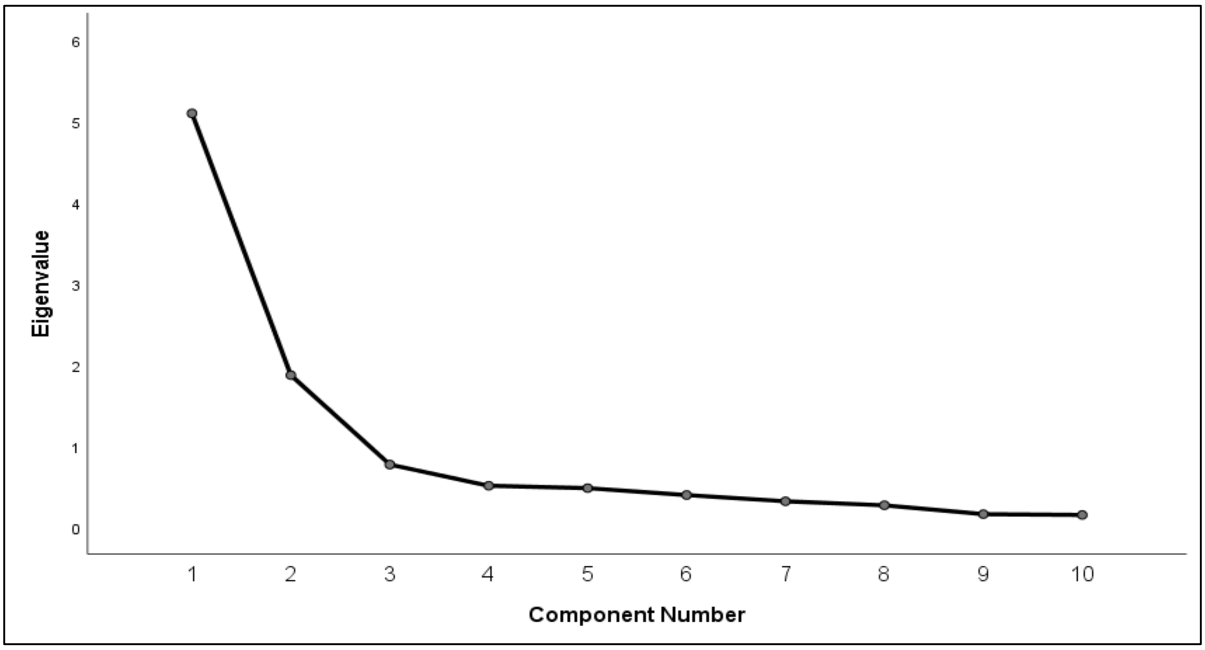

Figure 0.2: Catell's scree plot for tangible benefits of green building

According the loading pattern of the tangible benefits of a green building, findings disclose that *financial and utility benefit* converges at component 1, and *cost and technological benefit* converges at component 2 (Table 0.19).

✦ Component 1: *Financial and utility benefit*

Under the first component, due to inter-correlation, six benefits are related to *financial and utility benefit*, identified as *reduces energy consumption, preserves natural resources, reduces water consumption, promotes waste management, lowers operating cost* and *reduces tax payment* (Table 0.19 below).

Table 0.19: Pattern matrix for tangible benefits of a green building

Pattern Matrix (Tangible Benefits)	Component	
	1	2
It reduces energy consumption	0.966	
It preserves natural resources	0.944	
It reduces water consumption	0.947	
It promotes waste management	0.754	
It lowers operating cost	0.557	
It reduces tax payment	0.530	
It reduces maintenance cost		0.672
It reduces dilapidation in building		0.707
It provides for flexible design options due to varying technologies		0.946
It allows for central control of building activities		0.835

✦ Component 2: *Cost and technological benefit*

The last component includes four benefits: *reduces maintenance cost, reduces building dilapidation, provides flexible design option due to varying technology* and *allows central control of building activities* (Table 0.19).

4.12 Identifying the underlying intangible benefits of a green building concept on the value of a building

The analysis of underlying intangible benefits identified 10 variables perceived to potentially influence, positively or negatively, a green building. The procedure involved the application of the PCA analysis tool on the SPSS version 25. Analysis performed on the SPSS version 25, with the application of the PCA analysis tool, uncovered three components under this category, with eigenvalues greater than one.

Table 0.20: Total variance attained for intangible benefits of a green building

Component	Total	Initial Eigenvalues		Total	Extraction Sums of Squared Loadings		Rotation Sums of Squared Loadings Total
		% of Variance	Cumulative %		% of Variance	Cumulative %	
1	2.770	27.701	27.701	2.770	27.701	27.701	2.604
2	1.963	19.634	47.334	1.963	19.634	47.334	1.986
3	1.164	11.636	58.970	1.164	11.636	58.970	1.622
4	0.921	9.213	68.183				
5	0.803	8.028	76.212				
6	0.594	5.943	82.155				
7	0.548	5.478	87.633				
8	0.522	5.221	92.854				
9	0.391	3.911	96.765				
10	0.323	3.235	100.000				

The three components accounted for 58.97% of the total variance of the ten benefit criteria, as presented in Table 0.20. The assessment of the scree plot indicated a clear break after the third component. During the analysis, Promax rotation aided the interpretation of the three components, with results illustrating that the three components yielded a number of loadings above 0.3 on pattern matrix, as in

Table 0.21. The findings, according to the loading pattern of the intangible benefits of a green building, disclose that *health and productive benefit* converges at component 1, *economic benefit* converges at component 2 and *security benefit* converges at component 3.

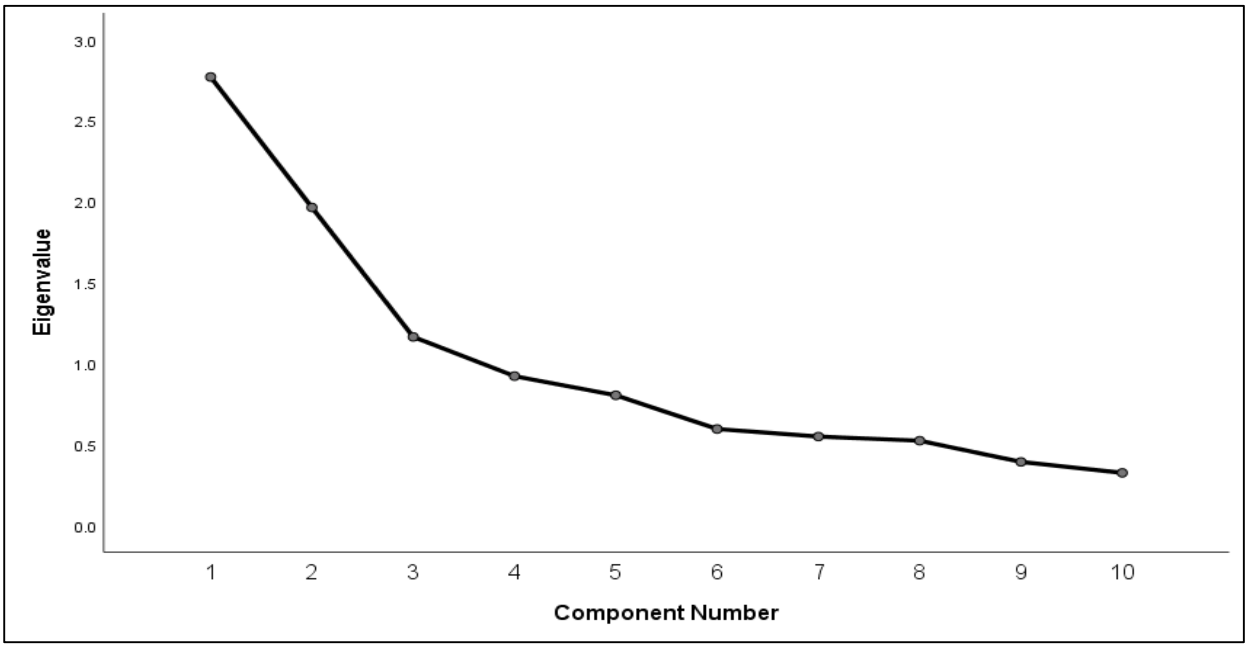

Figure 0.3: Catell's scree plot for intangible benefits of a green building

✦ Component 1: *Health and productive benefit*

In terms of the inter-correlation, five benefits are related to the *health and productive benefit* under the first component. These benefits are identified as *increases user productivity, improves building occupants' health, improves company brand equity and goodwill, reducesnegative environmental impact* and *reduced liability risk* (Table 0.21 below).

✦ Component 2: *Economic benefit*

This component includes three benefits, *improves indoor air quality, a good edge against economic inflation* and *technologically friendly and adaptive* (Table 0.21).

Table 0.21: Pattern matrix for intangible benefits of a green building

Pattern Matrix (Intangible Benefits)	Component		
	1	2	3
It increases user productivity	0.804		
It improves the health of building occupants	0.739		
It improves company brand equity and goodwill	0.790		
It reduces negative impact on environmental	0.597		
It reduces liability risk	0.515		
It improves indoor air quality		0.819	
It increases property value			0.760
It provides better security means for users			0.835
It has a good edge against economic inflation due to constantly changing technology		0.638	
It is technologically friendly and adaptive		0.751	

- Component 3: *Security benefit*

The last component is comprised of two benefits, including *increased property value* and *provides better security means for users* (Table 0.20).

4.13 Chapter summary

This chapter presented the results of data analysis for this study, encompassing the introduction to background information and the benefits of a green building, categorised as tangible and intangible benefits. This section analysed the green building features, its impact and influence on the value of a building, and current technologies adopted in green building. In addition, the method adopted in this study was appropriately discussed. On this note, the quantitative method was adopted to examine the influence of a green building concept on the value of a building. The statistical analysis techniques required to test and validate the hypotheses are discussed in the subsequent chapter.

CHAPTER FIVE

Hypotheses testing and discussion of findings

5.1 Introduction

This chapter discusses the testing of the hypothesis and findings attained thereof. In this section, the hypothetical test focuses on the tangible and intangible benefits of a green building, significant green building features that enhance the value of a building, and perceptions of respondents concerning current practices for valuing green building projects. Prior to testing hypotheses, the responses were first subjected to reliability analysis using Cronbach's alpha coefficient test. Three hypotheses were tested, and analysis of variance (ANOVA) statistical tool was adopted for this particular analysis.

Hypothesis 1: *There is a statistically significant difference between the perceptions of construction professionals regarding the tangible and intangible benefits of a green building.*

Hypothesis 2: *There is a significant difference between the perceptions of construction professionals regarding the most significant green building features that enhance the value of a building*.

Hypothesis 3: *The perceptions concerning current practices for valuing green building projects do not differ among construction participants.*

5.2 Reliability testing

The Cronbach's alpha coefficient was employed to evaluate the reliability of the scaled questions. The overall Cronbach's alpha coefficient for a number of scaled questions was between 0.5 and above, although it is important to note that the Cronbach's alpha values must be larger than 0.7, or at the least 0.6, for adoption in this study. This is because it would be statistically incorrect to create variables and simultaneously test variables where the Cronbach's Alpha is less than 0.6. Therefore, the intangible benefit represented as 'factor 3' in Table 0.2 below and the impact of green building features on value represented as 'factor 5' in Table 0.3 below were respectively omitted from hypotheses testing.

Table 0.1: Reliability test of tangible benefits of a green building

Reliability test of tangible benefits		
Factors	**Number of items**	**Cronbach's alpha coefficient**
Tangible benefit–factor 1 (Financial and utility benefit)	6	0.905
Tangible benefit–factor 2 (Cost and technological benefit)	4	0.809

Table 0.2: Reliability test of intangible benefits of a green building

Reliability test of intangible benefits		
Factors	**Number of items**	**Cronbach's alpha coefficient**
Intangible benefit–factor 1 (Health and productive benefit)	6	0.729
Intangible benefit–factor 2 (Economic benefit)	3	0.625
Intangible benefit–factor 3 (security benefit)	2	0.505

Table 0.3: Reliability test of green building features

Reliability test of green building features		
Factors	**Number of items**	**Cronbach's alpha coefficient**
GBF impact value–factor 1 (Eco-friendly material and energy conservation features)	7	0.807
GBF impact value–factor 2 (Water saving and renewable energy feature)	4	0.819
GBF impact value–factor 3 (Safety feature)	3	0.753
GBF impact value–factor 4 (Natural day light and control feature)	4	0.672
GBF impact value–factor 5 (Sun shade and light feature)	2	0.584
GBF impact value–factor 6 (Water management and flooring feature))	3	0.754
GBF impact value–factor 7 (Special utility feature)	3	0.621

5.3 Perceptions of the construction professionals on the tangible and intangible benefits of a green building

Hypothesis 1: *There is a statistically significant difference between perceptions of construction professionals regarding the tangible and intangible benefits of a green building.*

The procedure followed in testing hypothesis 1, requiring the application of a one-way between-group analysis of variance, was conducted to analyse the perceptions of the construction professionals about the tangible and intangible benefits of a green building. The survey participants were categorised into the following groups according to their professional background, namely green building/sustainability specialist, engineer, estate surveyor and manager, property manager, architect, town planner, foreman, building technician, quantity surveyor, project manager and site manager.

Table 0.4: Perceptions of construction professionals on the intangible benefits of a green building using ANOVA

ANOVA of the perceptions of construction professionals on the intangible benefits of a green building						
Intangible benefits of a green building		**Sum of squares**	**Df**	**Mean square**	**F**	**Sig.**
Intangible benefits–factor 1	Between groups	16.853	10	1.685	0.959	0.486
	Within groups	140.625	80	1.758		
	Total	**157.478**	**90**			
Intangible benefits–factor 2	Between groups	5.634	10	0.563	1.001	0.450
	Within groups	45.023	80	0.563		
	Total	**50.658**	**90**			

The results attained using ANOVA to determine the statistically significant difference for the intangible benefits, found in

Table 0.4, validate that there is no statistically significant difference at the $p < 0.05$ level between the perceptions of construction professionals regarding intangible benefits–factor 1 (0.486) and –factor 2 (0.450). In the case of tangible benefits, as displayed in Table 0.5, ANOVA results demonstrate that there is no statistically significant difference at the $p < 0.05$ level between the perceptions of construction professionals regarding tangible benefits–factor 1 (0.339), but a statistically significant difference between the perceptions of construction professionals and tangible benefit factor 2 (0.004) was determined.

Table 0.5: Perceptions of construction professionals on the tangible benefits of a green building using ANOVA

ANOVA of the perceptions of construction professionals on the tangible benefits of a green building						
Tangible benefits of a green building		**Sum of Squares**	**Df**	**Mean square**	**F**	**Sig.**
Tangible benefits–factor 1	Between groups	8.280	10	0.828	1.148	0.339
	Within groups	57.723	80	0.722		
	Total	**66.004**	**90**			
Tangible benefits–factor 2	Between groups	56.031	10	5.603	2.886	0.004
	Within groups	155.327	80	1.942		
	Total	**211.357**	**90**			

In addition, given that three out of the four factors yielded significant levels greater than 0.05, the interpretation of this finding means that *hypothesis 1 is rejected*.

5.4 Perceptions of construction professionals on the most significant green building features that enhance the value of a building

Hypothesis 2: *There is a significant difference between the perceptions of construction professionals regarding the most significant green building features that enhance the value of a building.*

A similar procedure was followed in section 5.3; in this section, perceptions of construction professionals on the most significant green building features enhancing the value of a building are analysed with the use of a one-way between-group analysis of variance. The results are displayed in Table 0.6.

Table 0.6: ANOVA of the impact of green building features on the value of a building

ANOVA of the perceptions of the construction professionals on the most significant green building features						
Impact of green building features on value		**Sum of Squares**	**df**	**Mean square**	**F**	**Sig.**
GBF impact value–factor 1	Between groups	2.534	3	0.845	1.997	0.120
	Within groups	36.807	87	0.423		
	Total	**39.341**	**90**			
GBF impact value–factor 2	Between groups	4.354	3	1.451	2.693	0.051
	Within groups	46.897	87	0.539		
	Total	**51.251**	**90**			
GBF impact value–factor 3	Between groups	6.429	3	2.143	2.981	0.036
	Within groups	62.536	87	0.719		
	Total	**68.965**	**90**			
GBF impact value–factor 4	Between groups	9.603	3	3.201	7.462	0.000
	Within groups	37.320	87	0.429		
	Total	**46.923**	**90**			
GBF impact value–factor 6	Between groups	10.180	3	3.393	5.609	0.001
	Within groups	52.631	87	0.605		
	Total	**62.811**	**90**			
GBF impact value–factor 7	Between groups	2.264	3	0.755	1.167	0.327
	Within groups	56.232	87	0.646		
	Total	**58.496**	**90**			

From the table, it observed that the perceptions of construction professionals do not differ in factors 1 (0.12), factor 2 (0.051) and factor 7 (0.327). To the contrary, however, the perceptions of construction professionals do differ with respect to factor 3 (0.036), factor 4 (0.000) and factor 6 (0.001). The test of null hypothesis (2) shows that the statistically significant difference in the perceptions of construction professionals is on the average, suggesting that the hypothesis may be accepted or rejected.

5.5 Perceptions on the current practices for valuing green building projects

Hypothesis 3: *The perceptions concerning the current practices for valuing green building projects do not differ among construction participants.*

The section discusses the ANOVA test carried out in determining whether or not perceptions concerning the current practice for valuing green building project differ significantly among construction participants. In Table 0.7, the ANOVA results of the perceptions regarding the current practices for valuing green buildings do differ concerning valuation method 2 (0.055), method 3 (0.425), method 4 (0.686), method 5 (0.251), method 6 (0.148) and method 7 (0.105). On the contrary, valuation method 1 (0.043) differs significantly among construction participants.

Table 0.7: ANOVA of perceptions on the current practices for valuing green building projects among construction participants

Valuation methods		Sum of squares	df	Mean square	F	Sig.
Income method	Between groups	29.466	10	2.947	1.986	0.043
	Within groups	139.449	94	1.483		
	Total	**168.914**	**104**			
Direct capitalisation method–factor 1	Between groups	19.043	10	1.904	1.897	0.055
	Within groups	94.347	94	1.004		
	Total	**113.390**	**104**			
Discounted cash flow analysis–factor 2	Between groups	9.332	10	0.933	1.030	0.425
	Within groups	85.182	94	0.906		
	Total	**94.514**	**104**			
Sales comparison method–factor 3	Between groups	8.497	10	0.850	0.739	0.686
	Within groups	109.239	95	1.150		
	Total	**117.736**	**105**			
Cost method–factor 4	Between groups	15.260	10	1.526	1.284	0.251
	Within groups	112.901	95	1.188		
	Total	**128.160**	**105**			
Building Sustainability Assessment (BSA) method–factor 5	Between groups	16.100	10	1.610	1.509	0.148
	Within groups	101.334	95	1.067		
	Total	**117.434**	**105**			

Comparative market analysis–factor 6	Between groups	20.398	10	2.040	1.649	0.105
	Within groups	117.536	95	1.237		
	Total	**137.934**	**105**			

The test of null hypothesis (3) illustrates statistically that there is no significant difference in the perceptions about the current practices for valuing green building among construction participants. In essence, they do not differ; hence, the hypothesis is supported.

5.6 Discussion of findings in the context of the literature review

5.6.1 Benefits of green building that influence the value of a building

The benefits of green building and its influence on the value of a building were examined in the literature review under two categories: tangible and intangible benefits. From the findings, the tangible and intangible benefits of a green building play a vital role in the determination of building value, primarily because these are key factors involving its increasing demand. With tangible benefits, only three top-ranked benefits of a green building demonstrated highest influence on the value of a building: *reduces energy consumption* with an MV of 3.98; *preserves natural resources* with an MV of 3.90; and *reduces water consumption* with an MV of 3.87. Birkenfeld *et al.* (2011: 4) and Mark (2005: 21) buttress these findings with previous studies carried out on tangible benefits, emphasising that this category of benefits influenced the value of a building as measured in monetary terms, such as energy savings or efficiency, reducing destruction of natural resources and reduction in water consumption.

In contrast, findings relating to intangible benefits indicate that only two top-ranked benefits of a green building demonstrated highest influence on the value of a building, from more of a major extent than a minor extent: *reduces environmental impact* with an MV of 4.03; *improves company brand equity and goodwill* and *increases property value* with an MV of 3.91. These findings are similar to previous studies by Birkenfeld *et al.* (2011: 4) who identified *improved company brand equity and goodwill* as well as *reduced environmental impact* as intangible benefits of green building.

Further findings indicate that tangible benefits can be classified as factor 1, which represents *utility and financial benefits,* and factor 2 which represents *cost and technological benefits,* whilst the intangible benefits can be classified as factor 1, which represents *health and productive benefits,* factor 2 represents *economic benefits,* and factor 3 represents *security benefits.*

Additionally, the results elicited from the respondents indicate that there is no statistically significant difference in the tangible and intangible benefits with respect to construction professional perceptions. This is because they are relatively significant. Although tangible benefits are often perceived on a short-term scale, intangible benefits are appreciated on a long-term basis. Furthermore, in respect to *cost, quality* and *usage,* findings gathered from questionnaire analysis indicate that more benefits are drawn based on *cost* and *usage* since these are quite visible and usually short-term to the extent of achieving relative cost reduction in terms of energy or water. Some respondents, though, identified *high cost of construction* and *maintenance of green building facilities*. On the other hand, *quality* is unseen and unavoidable in terms of standard rating as required by the green building council. Most importantly, an ample number of respondents commended the unique quality of a green building, including the provision of comfort and an environment conducive for work and home.

5.6.2 Green building features and the impact on the value of a building

The features of a green building and their impact on the value of a building is evaluated subject to the perceptions of the respondents on a scale of 1 to 5, ranging from least to most important features. Findings indicate that green building features with an MV above 3.00, such as *kitchen and WC water efficient fittings* with an MV of 3.91*, megawatt photovoltaic solar plant* with an MV of 3.79, and *water metering for monitoring and leak detection* with an MV of 3.74 are of more importance than least importance in influencing the value of a building.

Assessing from the MVs perspective, it is understood that these features have significant influence on the value of a green building.

As part of the findings derived, several components determined in the analysis of the green building features are categorised into seven related components in order to appropriately define their impact on the value of a building. The features include the following: *eco-friendly materials and energy conservation feature;* *water saving and renewable energy feature; safety feature*; natural *day light and control feature; sunshade and light feature; water management and flooring feature,* and *special utility feature*. Related studies conducted out by Maeda (2011:223), Petrone *et al.* (2012:227) and Hema (2012:33) also determined renewable materials, indoor air quality and recycled materials as green building features that make a significant impact in terms of the value of a building.

5.6.3 Impact of cost, quality and usage on the value of a green building

Findings accumulated through the literature review indicate that the impact of green building features on the value of a building was categorised in three groups, namely *cost, quality* and *usage* as discussed in Chapter 4. The results demonstrate that value of a green building, in terms of the *cost,* is essentially of more importance than of least importance since all the cost factor MVs are above 3.00. *Cost* assessment of a green building showed reduction in *life cycle cost of a building, utility cost of a building, and operating cost of a building* with each factor yielding an MV of 4.01, 3.93, and 3.89, respectively, and falling within the mean score range of > 3.40 ≤ 4.20, determined as 'between neutral to important/important'. The preceding results, in line with findings reported by IMT and AI (2013:4), revealed that the impact of green building features on the value of a building in terms of cost may lead to reduction in operating expenses such as lower utility bills while simultaneously increasing net operating income (NOI) – both of which have a positive effect on value.

Quality is another value assessment of a green building. The *quality* assessment of a green building is of more importance than of least importance, just as in the case of *cost,* since all quality factor MVs are above 3.00. The impact of this assessment has demonstrated that a green building *improves the quality of natural lighting* and *quality of indoor air, and reduces negative environmental impact* with each factor yielding an MV of 4.04, 4.03, and 3.83, and respectively falling within the mean score range of > 3.40 ≤ 4.20, determined as 'between neutral to important/important'.

The final of the three assessment categories is *usage,* wherein the assessment of a green building subject to this category exhibited a significant influence since all factors are above 3.00. The degree of influence of this category demonstrated that a green building *reduces water consumption, has more efficient energy usage,* and *promotes waste management* with each factor yielding an MV of 3.89, 3.81, and 3.67, and respectively falling within the mean score range of > 3.40 ≤ 4.20, determined as 'between neutral to important/important.

In a previous study by IMT and AI (2013:2), other related factors such as operating expenses, risk-mitigation and occupancy premiums were identified as additional assessment factors for a green building in categories of cost, usage and quality.

5.6.4 Current technologies adopted in green building

The findings show that 50% of the technologies yielded MVs above the midpoint of 3.00, a result indicating that the degree of importance of these technologies in influencing the value of a building is relatively fair as it is near average. Among the most ranked technologies are *solar power, Municipal Solid Waste* (*MSW),* and *Land Fill Gas* (*LFG)* with each of them yielding an MV of 4.14, 3.70 and 3.29, respectively. However, only the first two technologies fall within the mean score range of > 3.40 ≤ 4.20, determined as 'between neutral to effective/effective'. Other relevant factors fall within the mean score range of > 2.60 ≤ 3.40, graded 'between not so effective to neutral/neutral'. It can be concluded that *solar power* is frequently adopted in green building. With reference to previous studies by Platten (2011:5) and Ahmad (2016:11), green building technologies are categorised under five primary groups, with *one* of these categories being energy efficient technology which includes solar power that has been identified by respondents as *the* most effective technology in the current study. The other categories include water efficient technologies, indoor environmental quality enhancement technologies, material and resource efficient technologies and control systems. Roufechaei (2014:8) also classifies green technologies based on designer responsibility in aspects of architectural, mechanical and electrical.

5.6.5 Methods for determining the value of a green building

The assessment of the valuation methods used in determining the value of a green building demonstrated that some adopted methods yielded MVs above the midpoint of 3.00. This implies that these methods are more effective in determining the value of a green building, as discussed in section 4.9. Among these methods, *BSA, CMA, cost method,* and *sales comparison method* yielded MVs of 3.79, 3.71, 3.44, and 3.42, respectively. The range of the MVs produced fell within the mean score range of > 3.40 ≤ 4.20, graded 'between neutral to effective/effective'. Other adopted methods fell within the mean score of > 2.60 ≤ 3.40, determined as 'between not so effective to neutral/neutral', possibly due to challenges of valuing green buildings as suggested by Adomatis (2015:28), including the following:

- Impossibility of comparing ratings from numerous rating organisations, since different organisations adopt different 'rating systems.
- Since valuers depend on market data in valuing properties, a lack of data means lack of adequate information necessary for valuation.
- Using existing databases in green valuation assignments presents many difficulties.
- Residential properties constitute different problems due to relatively new occurrences of properties with green features in the market.
- Private databases cause problems in valuing green buildings.
- Risk and uncertainty abound.

Some challenges were pinpointed in relation to the influence of a green building concept on the value of a building and impact of green features. These challenges are outlined below:

- Some respondents complained about the cost and uncertainty in meeting required standards set by the green building council and SABS, as some emphasised that these requirements are high.
- There are often difficulties with getting the right specialists for maintenance and even for installations of some special green building gadgets.

- The maintenance costs are high due to demand for technology specialist services.
- Respondents claimed that while some materials are not suitable for use when constructing a green building, they are used to achieve green star ratings and standards.
- Another claimed that the cost implication associated with implementing a green construction building is extreme.
- The comparative cost of green buildings to the traditional method is high, only paying off in long term.
- It is difficult getting the right contractors and maintaining required site regulations.
- There is a high cost of labour due to required specialists and skills.
- Green building is highly capital-intensive to execute.
- The cost of required building materials is high because imported materials are frequently used.
- Registration of construction materials hinders green building completion because the process can be time consuming.
- Compiling a supply list can be challenging as registered by the green building council of South Africa.

5.7 Chapter summary

This chapter discussed the testing of hypotheses and findings emanating from the survey in context of the literature review in Chapter 2. It is important to highlight that the test of reliability was conducted to ascertain the consistency level of the scaled questions pertaining to the benefits (tangible and intangible) as well as the features of green building. With regard to hypothesis 1, the perception of construction professionals regarding the tangible and intangible benefits, tested using ANOVA, revealed that there was no significant difference between the perceptions of construction professionals concerning the benefits of GB. Hypothesis 2 examined the perceptions of construction professionals regarding the most significant green building features that enhance the value of a building. After the test, it was revealed that their perceptions hover on the average, implying that the hypothesis may be accepted or rejected. The third hypothesis tested the perceptions of construction participants regarding the current practice for valuing green building projects. From the test, results indicate that the perceptions among construction professionals with regard to current practice for valuing green building do not differ; hence, the null hypothesis was supported.

CHAPTER SIX

Conclusions and recommendations

6.1 Introduction

This chapter re-examines the aim and objectives of the study, reaches conclusions, and outlines the limitations of the study. Other areas to be discussed are practical implications, study recommendations, and suggested areas for further research as pertaining the influence of a green building concept on the value of a building. As stated in the preceding chapters, the aim of the study is to examine the influence of a green building concept on the value of a building, and to investigate the current practices in place for valuing green building. The outlined objectives in achieving the aim include the following:

1. to examine the benefits of green rated buildings in the building construction industry;
2. to identify and categorise the most significant green building features that enhance the value of a building;
3. to determine the extent to which green building features influence the value of a building;
4. to identify the current trends of green technologies adopted by the building industry in the construction of green buildings; and
5. to identify current practices adopted to value green buildings.

6.2 Conclusion relative to objectives

The concept of a green building encompasses ways of designing, constructing and maintaining buildings with the purpose of decreasing cost, energy and water usage, improving efficiency and longevity, and diminishing the burdens that building imposes on the environment and public health. The objectives of the study are strictly in line with the basic benefits of green rated buildings.

6.2.1 Benefits of green rated buildings in the building construction industry

To achieve this objective, a comprehensive review of literature was undertaken, with benefits of a green rated building categorised into two main groups: tangible and intangible benefits. According to the findings, the most significant green building benefits classified under ‘tangible benefits’ were *green building reduces energy consumption, preserves natural resources* and *reduces water consumption.* Similarly, the most significant green building benefits classified under intangible benefits were determined, such as *reduced negative environmental impact, by improved company brand equity and goodwill,* and *increased property value.*

Additional findings revealed that two components were derived from the application of the PCA relative to the tangible benefits of green building: *financial and utility benefit* and *cost and technological benefit.* In the case of the intangible benefits, three components were determined through a similar method: *health and productive benefit, economic benefit,* and *security benefit.* Conclusively, the value of any building will be directly or indirectly influenced by added benefits accrued through the adherence to green building concepts.

6.2.2 Most significant green building features that enhance the value of a building

The second objective of the study identified and categorised the most significant green building features that enhance the value of a building. This objective was achieved through the review of literature, administration of survey questionnaires to construction professionals, including civil engineers, architects, estate surveyors and managers, building technicians and experts, green building experts, quantity surveyors, land surveyors, property developers, construction site managers and supervisors.

A similar approach was used in determining the most significant green building features that enhance building value. The features determined are outlined in the order of importance in influencing or enhancing the value of a building: *kitchen and WC water efficient fittings, megawatt photovoltaic solar plant,* and *water metering for monitoring and leak detection.* The ranked categorisation of these features was achieved through exploratory factor analysis. Based on the PCA results, the features were narrowed down and grouped into the following seven factors, namely *natural and renewable features, energy efficient and hydro features, safely features, natural day light and control features, sunshade and light features, artificial water and flooring features,* and *special utility features.*

6.2.3 Extent to which green building features impact the value of a building

This particular objective is attained by determining the degree of significant impact on building value. Through this approach, therefore, the impact of the green building features on the value of a building was explored through three assessment categories: *cost, quality* and *usage.* Findings indicated that factors such as *reduction in life cycle cost of a building, reduction in utilities cost* and *reduction in operating cost* have the primary impact on the value of a building in terms of the *cost.* Similarly, with the assessment of the *quality* in green building, the factors with extensive impact on the value of a building were determined: *improving the quality of natural lighting, improving indoor air quality* and *reducing negative environmental impact.* In respected to *usage,* the factors with the greatest impact on the value of a building were also determined: *reduce water consumption, reduce energy usage* and *promote waste management.*

6.2.4 Current trends of green technologies adopted by the building industry for the construction of green buildings

This objective determines the current trend of green technologies adopted by building industry for the construction of green buildings, based on the extent or frequency of adoption in terms of use. According to the findings, the green technologies adopted are ranked in the order of importance in connection with the current trends in green building: *solar power, municipal solid waste and land fill gas, hydro power, biomass, geothermal methods, ocean (Tidal) energy,* and *wind (Aeolic).*

6.2.5 Current practices in valuing green buildings

This objective examines the order of importance of various valuation methods adopted by construction professionals as the current practices in valuing green buildings. Findings indicate that *building sustainability assessment (BSA) methods, comparative market analysis (CMA – a computer-based method), and cost method* were determined as the most significant methods currently practised in valuing green building.

6.3 Conclusions relative to the research hypotheses

The context of this study focused on the influence of a green building concept in enhancing the value of a building. The conclusions derived from the findings discussed in the preceding subsections, presented in section 6.2, demonstrate that most construction professionals respond affirmatively about the impact of a green building concept in enhancing the value of a building including, its eco-friendly advantages as long-term benefits. However, the perception of other several construction professionals warn about the cost associated with the implementation of these features. The hypothesis formulated and tested in the study concerned whether or not the construction professional perceptions differ regarding the benefits and most significant green building features that enhance the value of a building, together with the current practice for valuing green building projects.

Hypothesis 1: *There is a statistically significant difference between the perceptions of construction professionals regarding the tangible and intangible benefits of a green building.*

The findings from the testing of hypothesis 1 demonstrate that there is no statistically significant difference at the $p < 0.05$ level between perceptions of construction professionals on the tangible and intangible benefits of a green building, as the ANOVA results show that significant values of 0.486 and 0.450 for intangible benefits–factor 1 and 2, including a significant value of 0.339 obtained for tangible benefits–factor 1, are above the significant level of 0.05. To the contrary, a significant value of 0.004 for tangible benefits–factor 2 is detected, which is statistically below the significant level of 0.05. In that case, the hypothesis is rejected.

Hypothesis 2: *There is a significant difference between the perceptions of construction professionals regarding the most significant green building features that enhance the value of a building.*

The findings attained from the testing of the hypothesis 2 show that the statistically significant difference at the $p < 0.05$ level can be considered average or even. This is due to the significant values generated from the green building features. Accordingly, significant values of 0.120, 0.051 and 0.327 were generated for factor 1, factor 2 and factor 7, respectively, which are above the significant level of 0.05. To the contrary, there is a significant difference between the perceptions of construction professionals in regard to the impact if green building features on building value factor 3 (0.36), factor 4 (.000) and factor 6 (.001). Therefore, this hypothesis can either be accepted or rejected.

Hypothesis 3: *Perceptions concerning current practices for valuing green building projects do not differ among construction participants.*

The results from the testing of the hypothesis 3 indicate no statistically significant difference at the $p < 0.05$ level of the perceptions on the current practices for valuing green building projects among construction participants, since the ANOVA results achieved demonstrate that significant values of 0.043, 0.055, 0.425, 0.686, 0.251, 0.148 and 0.105 for income method–factor 1, direct capitalisation method–factor 2, discounted cash flow analysis–factor 3, sales comparison method–factor 3 (market approach), cost method–factor 4, building sustainability assessment (BSA) method–factor 4, and comparative market analysis (CMA)–factor 5, respectively, are greater than the significant level of 0.05. Thus, the hypothesis is supported.

6.4 Limitations

First, this study was conducted only in the Western Cape Province of South Africa. The collection of data at various construction sites was a challenging task, particularly within the survey and data gathering period, primarily attributable to the limited availability of selected respondents. Most complaints from professionals were regarding their tight time schedules, site meeting attendance and pressures of project completion dates. All these elements affected the timely completion of the questionnaires. Some questionnaires were returned incomplete and some unattended, so some information gathered may be inadequate for broadening the unique scope of this study. Another issue encountered was the time constraint for the completion of the entire study programme.

6.5 Practical implications and recommendations

This study contributes considerably to the adoption and application of a green building concept and its impact on the value of a building. According to Guy and Shove (2000: 133), "it is not simply a question of transferring technologies upon people. Instead, knowledgeable actors creatively adopt and adapt strategies and practices that suit their changing circumstances. Sometimes these favour (the environment), sometimes not". This study contributes to the process of understanding the relative benefits of green building, in terms of tangible and intangible benefits, and inherent value of green building features, through the adoption of valuation methods and adaptation processes by end users and professionals within the building construction industry.

Certain basic challenges and controversies emanated from the findings of this study, such as the following:

- Green building projects are typically capital intensive; hence, a green building can be expensive to erect even though its operation is sustained relatively inexpensively.
- Building value is often cost related; thus, due to increased costs of required materials, the value will appreciate. Moreover, the materials required for green building construction may be scarce and therefore, be expensive.
- Poor awareness of the concept of green building may have negative effect on actual value.
- The implementation process of the concept is highly demanding due to the specialised labour skills required.
- The valuation process can be complicated due to specialised designs and concepts.
- Due to constantly evolving technology, the sustainability of green building concept is challenging.
- The high rating standards by the GBCSA can be challenging for upcoming professionals.
- The installation of green building facilities can be time consuming.

It will be logical to claim that the green building concept represents a unique kind of construction practice; so, to address the changes in built environment, developers and users demand new techniques to understanding and promote its concept and adoption. This research study suggests that the adoption of a green building concept not only involves a change in perception and kinds of practices employed, but also must entail awareness concerning the influence on the value of a building.

The practical relevance of the impact of a green building concept on the value of a building stimulates an environment conducive to building construction and excellent valuation to raise the quality, lower the cost and encourage excellent usage of a building. The findings that emanate from this study are practically applicable in comprehending the need to adopt a green building concept and in valuation methods for determining its impact on a building value. The study has provided awareness for a host of professionals – property developers, engineers, quantity surveyors, estate surveyors and valuers, architects, green building experts, research and educational institutions and contractors – with regard to the influence of a green building concept on the value of a building.

Based on the findings and aforesaid practical implications, the following recommendations stimulate awareness for end users and construction professionals in the building industry, with the purpose of implementing a green building concept for improving practice and attaining the best value of a building. Design and construction firms should institute a mechanism for valuing green building based on added benefits and features, thereby determining a building value based on the influence of a green building concept, since green buildings are often aimed at sustainability and environment friendly initiatives.

Therefore, it is recommended that the users, construction professionals, and others within the built environment not overlook the relative advantages of a green building. In this study, the benefits of green building were divided into tangible and intangible benefits, such as less water and energy consumption, preservation of natural resources, reduced operating cost, reduced negative environmental impact, increased property value, reduced liability risk, increased user productivity, improved health of building occupants, and most importantly, financial security benefits.

Some of the most significant actions for promoting a green building concept are the development of new strategies to promote the awareness of users, construction professionals, developers and others in the built environment, concerning the benefits of a green building and added value due to special features, such as water metering to enable monitoring, megawatt photovoltaic solar plants, electrical sub-metering used for individual billing purposes, timber flooring, the use of daylight censored high performance chilled water, atrium roof lights, light shelves, biometric reader system (BRM) and more as discussed earlier above. Another aspect that should be promoted by the construction industry and the green building council is the adoption of green building technologies, such as solar power, the use of land fill gas (LFG), hydropower/ocean energy, biomass and geothermal methods, wind (Aeolic) energy, and other forms of green technologies.

Moreover, awareness should be accelerated concerning the impact of a green building concept on the value of a building. In view of this, the impact of a green building concept is acknowledged around three assessment categories – cost, quality and usage. Cost assessment on a green building yielded reduction in the life cycle cost of a building, reduced utility, operating, management and maintenance cost, increase in revenue, reduced liability risk, reduced occupancy premium, and reduced tax payments. In respect of quality assessment, factors yielded are improved quality of natural lighting, indoor air quality, reduced negative environmental impact, and promotion of company brand and goodwill. Then, usage assessment yielded reduced energy and water consumption, access to natural views, minimised risk and improved productivity, regulated draft, noise and floor stratification, and improved health of building occupants.

The construction industry and the Green Building Council of South Africa are expected to establish initiatives that cultivate enabling environments for the adoption of a green building concept by professionals and users. The important step is to incorporate the inherent value of green rated buildings into the methodology adopted for valuation. This will ensure clarity in the added value emanating from the use of green building concept. In that case, all the assessment methods categorised under valuation methods should be considered for the valuing of green features, its benefits, and the application of a green building concept, with the intention of demonstrating its influence on a building value.

Research and educational institutions should encourage more studies regarding the development of new green building concepts yielding eco-friendly products, and training of professionals. Furthermore, better training and education opportunities on an actual green building concept and its value on building (active and passive) at tertiary and professional levels would propel more awareness. Also, professional bodies should expand the knowledge base and technical capacity of professionals through awareness programmes and accreditation of institutions and practitioners. Ultimately, as the financial assessment of a green building has proven challenging for developers and interested professionals, it is recommended that financial institutions should support developers by providing them with green lending incentives. In due course, this will enhance the benefit of developing technical know-how in guaranteeing green projects, valuing the unique nature of such projects, and developing commercial lending programmes to provide access to capital for developing green buildings.

6.6 Contribution to the body of knowledge

The primary objective of this research is to bridge the identified gap in the extent of awareness and valuation of a green building concept in South Africa, with the intent of bolstering the application and acceptability of a green building concept, including its influence on the value of a building, with respect to green building as an evolving construction practice.

This research provides insight into the actuality of green building benefits and its features. Also, the study depicts how the value of a green building concept is crucial in achieving the inherent and actual value of a building, holding to the uniqueness of a green concept as a construction innovation. However, the knowledge-gap between the findings from this study and previous studies remains as a lack of evidence attributed to the influence of a green building concept on the value of a building. In addition, the recent findings from this research contribute to better understanding of the influence of a green building concept on the value of a building.

6.7 Areas for future research

The relevance of this research should be extended to the national level, because the perceptions of construction professionals across South Africa may differ. This effect will render a broader perspective of the influence of a green building concept on the value of a building nationally, not just in the Western Province. Other recommended future research areas should cut across the importance of finding a better way of implementing effective valuation methods and determining other relevant strategies for the purpose of building features due to rapid development.

6.8 Chapter summary

This chapter discusses the concluding parts of the entire study by integrating the findings coherently to fathom appropriate recommendations required in supporting that South African construction professionals be informed concerning the influence of a green building concept on the value of a building. The areas integrated cut across the concluding association between the benefits of green rated buildings, the most significant green building features and their impact on the value of a building, and the current green technologies adopted. The discussion was extended to current practices in valuing green buildings, research hypotheses, limitations, practical implication and recommendations, knowledge contribution and future research.

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Appendix A

Cape Peninsula
University of Technology

DEPARTMENT OF CONSTRUCTION MANAGEMENT

25TH JULY 2018

Dear Madam / Sir

Re: The influence of a green building concept on the value of a building

This survey is part of a research project aimed at meeting the requirement for an Master of construction (Construction Management) at the Cape Peninsula University of Technology.

The aim of this phase of the research project is to examine the influence of a green building concept on the value of building, as well as investigate the current practices in place for valuing green building.

The questionnaire should **not take more than 15 to 20 minutes** to complete, and we would be grateful if you would endeavour to complete the questionnaire and return it on or before **15th August 2018** to:

Department of Construction Management and Quantity Surveying
Cape Peninsula University of Technology
PO Box 1906
Bellville
7535

Attention: Mr. Faith Owoha
Per e-mail to: owohafaith@gmail.com

Should you have any queries please do not hesitate to contact Mr. Owoha Faith at 0604529364 or per e-mail: owohafaith@gmail.com .

Please note that your anonymity is assured i.e. your individual response will not become public knowledge.

Thanking you in anticipation of your response.

Appendix B

Cape Peninsula University of Technology

QUESTIONNAIRE

THE INFLUENCE OF A GREEN BUILDING CONCEPT ON THE VALUE OF A BUILDING

SECTION A: BACKGROUND INFORMATION OF RESPONDENTS

1. Please indicate your highest qualification

If **'other',** please specify:

____

Matric cert.	N Diploma	BTech/BSc	BSc (Hon)	MSc/MTech	PhD/DTech	Other

2. Please record your occupation/profession:

____

3. Please record the length of time you have worked for your current employer:

Less than 5 years	5 to 10 years	Over 10 years

4. Please record the length of time you have worked in construction:

Less than 5 years	5 to 10 years	Over 10 years

5. Has your firm / organisation adopted the use of green building concepts?

Yes	No	Unsure

6. On a scale of 1(**not often**) to 5 (**very often**) how often do you work on green building projects (Please note the unsure option)?

Unsure	Not often.………………..…Very often				
	1	2	3	4	5

SECTION B: BENEFITS OF GREEN BUILDING

7. On a scale of **1(Minor)** to **5 (Major)**, to what extent does the following benefits associated with green building influence the value of a building in South Africa **(please note the 'unsure' response)**?.

7.1	**Tangible benefits**	**Unsure**	**Minor…....………………Major**				
			1	**2**	**3**	**4**	**5**
7.1.1	It reduces energy consumption	U	1	2	3	4	5
7.1.2	It preserves natural resources	U	1	2	3	4	5
7.1.3	It reduces water consumption	U	1	2	3	4	5
7.1.4	It promotes waste management	U	1	2	3	4	5
7.1.5	It lowers operating cost	U	1	2	3	4	5

7.1.6	Tax payment is reduced	U	1	2	3	4	5
7.1.7	It reduces maintenance cost	U	1	2	3	4	5
7.1.8	It reduces dilapidation in building (e.g. the use of glaze glass, monolithic walls, etc.)	U	1	2	3	4	5
7.1.9	It provides for flexible design options due varying technologies	U	1	2	3	4	5
7.1.10	It allows for central control of building activities (e.g. the use of central biometric system).	U	1	2	3	4	5

	Intangible benefits	Unsure	Minor…...………………Major				
7.2			**1**	**2**	**3**	**4**	**5**
7.2.1	It increases user productivity	U	1	2	3	4	5
7.2.2	Improved health of building occupants	U	1	2	3	4	5
7.2.3	Improved company brand equity and goodwill	U	1	2	3	4	5
7.2.4	Reduced negative environmental impact	U	1	2	3	4	5
7.2.5	Reduced liability risk	U	1	2	3	4	5
7.2.6	Improves indoor air quality	U	1	2	3	4	5
7.2.7	Increased property value	U	1	2	3	4	5
7.2.8	It provides better security means for users (e.g. central lock and alarm system)	U	1	2	3	4	5
7.2.9	It has a good edge against inflation due to constantly changing technology	U	1	2	3	4	5
7.2.10	It is technologically friendly and adaptive	U	1	2	3	4	5

SECTION C: GREEN BUILDING FEATURES AND THE IMPACT ON THE VALUE OF A BUILDING

8. On a scale of **1 (Least important)** to **5 (Most important),** and based on your professional experience and practice, what are the most important green building features that promotes the value of a building? **(Please note the 'Unsure' option)**.

	Features	Unsure	Least important…….Most important				
			1	**2**	**3**	**4**	**5**
8.1	The use of daylight censored high performance chilled water	U	1	2	3	4	5
8.2	Economy cycle water recycling systems (e.g. rain water and grey water harvesting)	U	1	2	3	4	5
8.3	Kitchen and WC water efficient fittings (e.g. censored taps, grey water collector)	U	1	2	3	4	5
8.4	Recycled glass and steel	U	1	2	3	4	5
8.5	Renewable materials like bamboo and rubber	U	1	2	3	4	5
8.6	High performance building façade and skylight	U	1	2	3	4	5
8.7	Heating and cooling provided by a 3-pipe variable refrigerant flow (VRF) system	U	1	2	3	4	5
8.8	Carpets made from 100% recycled material	U	1	2	3	4	5
8.9	Wind energy (e.g. wind turbines and wind power plant)	U	1	2	3	4	5

8.10	Photovoltaic solar panel system on building roof	U	1	2	3	4	5
8.11	Megawatt photovoltaic solar plant	U	1	2	3	4	5
8.12	Electrical sub-metering used for individual billing purposes	U	1	2	3	4	5
8.13	Electric car and bicycle charging points	U	1	2	3	4	5
8.14	Biometric reader system (BRM)	U	1	2	3	4	5
8.15	Black water recycling system	U	1	2	3	4	5
8.16	Water metering for monitoring and leak detection	U	1	2	3	4	5
8.17	Vegetation efficient drip irrigation system	U	1	2	3	4	5
8.18	Borehole water and reverse osmosis plant cyclist and shower facilities	U	1	2	3	4	5
8.19	The use of roof light (e.g. tear drops)	U	1	2	3	4	5
8.20	The use of inverters, (a multi split air conditioner e.g. VRV III) to enable individual zone control	U	1	2	3	4	5
8.21	Recycled cork panels and flooring	U	1	2	3	4	5
8.22	The use of sunglasses	U	1	2	3	4	5
8.23	Triple-glazed windows	U	1	2	3	4	5
8.24	Timber flooring from a certified plantation	U	1	2	3	4	5
8.25	Atrium roof lights	U	1	2	3	4	5
8.26	The use of light shelves	U	1	2	3	4	5

9. On a scale of 1 (**least important)** to 5 **(most important),** and based on your professional practice, what aspect do you think have the greatest potential impact on the value of green building

9.1	**Aspects:** **Cost**	**Unsure**	**least important ……most important**				
			1	**2**	**3**	**4**	**5**
9.1	It reduces operating cost	U	1	2	3	4	5
9.2	It increases revenue	U	1	2	3	4	5
9.3	It reduces maintenance cost	U	1	2	3	4	5
9.4	It reduces liability risk	U	1	2	3	4	5
9.5	It reduces the life cycle cost of a building	U	1	2	3	4	5
9.6	It reduces utilities cost	U	1	2	3	4	5
9.7	It lowers production cost	U	1	2	3	4	5
9.10	It reduces tax payment	U	1	2	3	4	5
9.11	It reduces management cost	U	1	2	3	4	5
9.12	It reduces occupancy premium	U	1	2	3	4	5
9.13	It lowers service charge	U	1	2	3	4	5
	Quality	**Unsure**	**1**	**2**	**3**	**4**	**5**
9.2.1	Improves indoor air quality	U	1	2	3	4	5
9.2.2	It improves the quality of natural lighting	U	1	2	3	4	5
9..2.3	It preserves natural resources	U	1	2	3	4	5
9.2.4	It improves company brand	U	1	2	3	4	5

9.2.5	It promotes company's goodwill	U	1	2	3	4	5
9.2.6	It reduces negative environmental impact	U	1	2	3	4	5
	Usage	**Unsure**	**1**	**2**	**3**	**4**	**5**
9.3.1	It increases user productivity	U	1	2	3	4	5
9.3.2	Energy usage is more efficient	U	1	2	3	4	5
9.3.3	It reduces water consumption	U	1	2	3	4	5
9.3.4	It provides access to outdoor natural views	U	1	2	3	4	5
9.3.5	It reduces drafts (A device that regulates the flow or circulation of air).	U	1	2	3	4	5
9.3.6	It reduces noise as materials such as glaze glasses, mass concrete walls, etc. are used.	U	1	2	3	4	5
9.3.7	It minimises floor-to-ceiling temperature stratification	U	1	2	3	4	5
9.3.8	Improved health of building occupants	U	1	2	3	4	5
9.3.9	It minimises/reduces risk	U	1	2	3	4	5
9.3.10	It promotes waste management	U	1	2	3	4	5

If other please state: ____

____

____

CURRENT TECHNOLOGIES ADOPTED IN GREEN BUILDING

10. On a scale of **1 (not effective)** to **5 (very effective)**, to what extent do you agree that the following technologies adopted by practicing firms ensure an easy, effective execution and implementation of green building projects/features?

	Technology	**Unsure**	**Not effective…...…Very effective**				
			1	**2**	**3**	**4**	**5**
10.1	Wind (Aeolic)	U	1	2	3	4	5
10.2	Geothermal methods	U	1	2	3	4	5
10.3	Ocean (Tidal) Energy	U	1	2	3	4	5
10.4	Hydropower	U	1	2	3	4	5
10.5	Biomass	U	1	2	3	4	5
10.6	Land Fill Gas (LFG)	U	1	2	3	4	5
10.7	Solar Power	U	1	2	3	4	5
10.8	Municipal Solid Waste (MSW)	U	1	2	3	4	5

…In case of others, please state

____

____

____

____

____

____

11. Due to the specialised nature of green building, do you often encounter challenges in the execution and implementation of the concept?

Yes	No	Unsure

11.1 If 'Yes', please state some of these challenges?

____
____
____
____
____
______

CURRENT PRACTICE FOR DETERMINING THE VALUE OF GREEN BUILDING

12. Please rank the following methods that are used in determining the value of green building from **1(least effective) to 5 (most effective)** in the column provided, please note that no number must be repeated.

S/N	Valuation methods	1	2	3	4	5
12.1	Income method/approach					
12.1.1	Direct capitalisation method					
12.1.2	Discounted cash flow analysis					
12.2	Sales comparison method or approach (also known as the market approach)					
12.3	Cost method (e.g. cost of land, cost of construction)					
12.4	Building Sustainability Assessment (BSA) methods					
12.5	Comparative market analysis (CMA), a computer based method.					

13. Do you have any specific technique adopted by your profession for easy determination of the value of green building features?

Yes	No	unsure

13.1 If 'Yes', please state techniques/concepts?

____
____
____
____

14. Do you have any comments in general regarding the influence of a green building concept on the value of a building?

____
____

____

____

Please record your details below to facilitate contacting you, in the event that the need arises.

Please note; every data provided in this questionnaire will be treated in the strictest confidence.

AGE*: ___________________________________

GENDER: ________________________________

ORGANISATION:

____

ADDRESS: ____

CELL*: ____

FAX ____

EMAIL ____

DATE: ____

Thank you for your contribution.