Minor Dissertation

An investigation into the impact of green low-cost social housing on the well-being of occupants in South Africa

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Submitted in partial fulfilment towards the completion of the Degree of Master of Science in Project Management in the Department of Construction Economics and Management, University of Cape Town

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2023

Abstract

Climate change and economic challenges have intensified global efforts to accelerate the adoption of green building for sustainable development and the reduction of poverty through efficient uses of energy, protection of ecosystems and preservation of natural resources. The necessity for green building has evolved from being a choice of convenience and luxury to an obligation to a global society that is increasingly growing environmentally conscious. The benefits of green buildings in the commercial sector have been extensively researched, often focusing on productivity, return on investment and operating costs. However limited literature exists that investigates the relationship between green buildings and occupant well-being in a residential context. This study aimed to address the identified research gap by identifying various green-rated, low-cost social housing developments in South Africa and interviewing their occupants to investigate the impact that green buildings have on their perceived well-being and whether their environmental outlook was influenced by occupying a green building.

A qualitative research method was adopted based on a review of the literature on green buildings and the subjective nature of well-being. Data collection was achieved via semi-structured interviews in the form of multiple case study analysis, where thematic analysis was applied.

The findings suggest that a positive relationship exists between green buildings and occupant well-being as well as their environmental awareness. Respondents reported experiencing improvements in areas that they considered contributory to their well-being and a noticeable positive change in their environmental awareness.

Future research should investigate standardised tools for measuring occupant well-being in green residential buildings using larger sample sizes and a wider range of income groups as this study was limited to low-income groups within the social housing sector.

Acknowledgements

I would like to thank everyone who assisted in making this research possible. Firstly, I would like to thank my mother for her unwavering support during these last 2 years. It was through her prayers and encouragement that I was able to continue pushing even when I felt overwhelmed and thought of giving up.

Secondly, my sincere gratitude goes to my supervisor, Mr Saul Nurick, whose patience and guidance carried me through this research task which at times seemed daunting.

Lastly, I am enormously indebted to the individuals who agreed to participate in this study. I am tremendously grateful for the time and valuable insight that they provided.

CON5023Z

Declaration

I know that plagiarism is wrong. Plagiarism is using another's work and pretending that it is one's own.

I have used the Harvard convention for citation and referencing. Each contribution to and quotation in this assignment from the work(s) of other people has been attributed, cited, and referenced.

This assignment is my own work.

I have not allowed, and will not allow anyone, to copy my work with the intention of passing it off as his or her own work.

Signed by candidate

Lwazi Zulu: ZLXLWA005

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List of abbreviations

BNG	Breaking New Ground
CO_2	Carbon Dioxide
CRU	Community Residential Units
EA	Environmental Attitude
FEC	Final Edge Certification
FLISP	Finance-Linked Individual Subsidy Programme
GB	Green Building
GBCSA	Green Building Council of South Africa
GDP	Gross Domestic Product
HVAC	Heating, Ventilation and Air Conditioning
IAQ	Indoor Air Quality
KWH	Kilowatt-Hour
LED	Light-emitting diode
NBR	National Building Regulations
NDP	National Development Plan
NEP	New Ecological Paradigm
NPC	National Planning Commission
PEC	Preliminary Edge Certification
RDP	Restructuring Development Programme
SANS	South African National Standards
WGBC	World Green Building Council

Chapter 1: Introduction

1.1 Introduction

The occupant benefits of green building and sustainable design in commercial buildings have been extensively covered in the literature (Katzenbach *et al.*, 2014; Windapo, 2014; Moore, Nicholls, *et al.*, 2017; Bao *et al.*, 2021; Nzube and Lyu, 2021), however, limited research exists that studies the relationship between the well-being of occupants of green social housing developments and their level of environmental awareness and attitude towards the role green buildings play in ensuring sustainability. The available literature predominantly focuses only on the occupants of commercial green buildings and not residential properties (Allen *et al.*, 2015; Mokhtar Azizi *et al.*, 2015; Wu *et al.*, 2016; MacNaughton *et al.*, 2017; Dwaikat and Ali, 2018; Doan *et al.*, 2019; Kim and Kim, 2020).

The purpose of this report is to outline the different points to be investigated in this research and forms Chapter 1 of a mini dissertation. The objective of the research is to investigate the relationship between green buildings and the well-being and environmental awareness of occupants, specifically focusing on low-cost social housing developments.

To achieve the above objective, the report provides an overview of the different housing subsidies that the South African government grants, followed by an introduction to green building and its definition. The next section focuses on green buildings within a South African context as well as the certification body and rating system used to determine the level of green in developments. The supposed benefits of green buildings are presented followed by a discussion on environmental awareness. The last point of the discussion covers available literature and a discussion on how attitude is quantified to determine the level of environmental awareness held by occupants of green buildings.

The literature covered in the proposal will create the necessary grounds for a research problem, question, proposition and aim to be established. Research objectives, methodology and limitations will be stated, and to conclude the chapter, a list of references will be provided followed by an outline of the research report structure.

1.2 Background

1.2.1 South African subsidised housing history and types of subsidies

The continuous rise in the population of South Africa coupled with the under-supply of housing that was inherited by the democratic government from the apartheid regime has resulted in rapid growth in the demand for government access subsidised housing programmes (Goebel, 2007b). The by-product of the housing demand increase has been a rise in greenhouse gasses (GHS) emissions as a result of producing the raw materials required for construction such as the manufacturing of reinforcement steel, plastic components, cement, and bricks as well as producing the energy which is used in completed homes (Tissington, 2011).

Tissington (2011); and Mabin (2021) provide an overview of some forms of social housing schemes that are granted subsidies by the South African government. Fully subsidised housing is 40m^2 units that are built by the private sector on behalf of the government and provided to households earning less than R3500 monthly, these are commonly known as RDP or BNG developments. Community Residential Units (CRU) are targeted at households with a combined income of less than R3500 per month, the project is aimed at rehabilitating and upgrading hostels and buildings located in the inner cities, where the units are not for sale but are rented out to households (GroundUp, 2017). Subsidised rental housing targets citizens earning above R3500 but less than R7500 monthly. These units are distributed to the public through government-selected social housing institutions (Tissington, 2011).

1.2.2 History and definition of green building

The origin of Green Building (GB) dates to the 1960s environmental movement and the energy crisis of the 1970s, a period that prompted the devising and prioritising of methods to reduce pollution of the environment and the improvement of energy efficiency in building construction (Mao *et al.*, 2009). The use of green building practices is not novel and can be traced as far back as the eighteenth century when buildings such as the Galleria Vittorio Emanuele in Milan and the Crystal Palace in the city of London regulated interior air temperature through cooling chambers located underground and ventilators on the roof (Federico Montella, 2008; Schoenefeldt, 2008).

In present-day construction, as the globe continues to endure environmental challenges such as climate change, pollution, the degradation of land and deforestation, the emphasis on greener

approaches has in part, been encouraged by the criticisms levelled against the construction industry as being at the forefront of the exploitation of excessive amounts of natural resources and primary energy, thereby affecting the environment, human health and economies (Doan *et al.*, 2017). A recent report by Architecture 2030 (2018) found that the building sector is responsible for an estimated 40 per cent of CO_2 emissions annually. This estimate indicates a large increase in CO_2 emissions over the last decade when considering that in 2007 the global estimate was 30 per cent (UNEP, 2007b). The global community both in developed and developing countries has recognised the importance of working towards sustainable development and embracing green building for a sustainable future (Korkmaz *et al.*, 2009).

The green building concept holds a multitude of definitions by institutions and scholars that are all driven by environmental consciousness and preservation. The (World Green Building Council (WGBC), 2019) defines green building as the process of limiting adverse climate and environmental impacts throughout the entire lifecycle of a building. Ashuri and Durmus-pedini (2010) define it as the promotion of environmental, health and community well-being. Green building is a step towards sustainable development, it is the efficient use of resources to satisfy present-day needs without hindering the ability of future generations to do the same (Brundtland Commission Report, 1987). Green building is environmental preservation, awareness of the well-being of occupants in a building, considering both air quality and utilisation of space. It seeks to achieve harmony between the building, the environment and the improvement of life (Zhang *et al.*, 2019).

1.2.3 Green building in a South African low-cost housing context

Like many developing countries, the South African construction industry holds significant economic and social importance through the creation of employment, and the provision of infrastructure to support other industries and contribute to the Gross Domestic Product (GDP) (Wibowo, 2003). The industry is also influential in shaping the population's society and economy through the provision of housing, institutions of learning and hospitals (Ofori, 2012).

Climate change and economic challenges have intensified global efforts to accelerate the adoption of green building for sustainable development and the reduction of poverty through efficient uses of energy, protection of ecosystems and preservation of natural resources. In South Africa, challenges such as water shortages, consistent load-shedding and extreme weather temperatures have put pressure on the building sector to adopt and implement green

building practices (Simpeh, 2018b). This is because developing countries such as South Africa consume natural resources and energy at an intensive rate, as these processes greatly contribute to land, water and air pollution (Oguntona, 2019). The requirement for green building has shifted from being a choice of convenience and luxury and has evolved into an obligation to a global society that is increasingly growing environmentally conscious (Ashuri and Durmus-pedini, 2010). As a developing country, South Africa recognises the importance of sustainability, this has led to the formation of institutions such as the Green Building Council of South Africa (GBCSA) and the implementation of standards such as SANS 10400-XA and SANS 204 that aim to guide industry practitioners in matters of energy efficiency and sustainability in the design of buildings, which is especially crucial in low-income housing.

Research indicates that low-income households are severely impacted by continuously increasing energy costs, this is because their financial situation often results in the inability to pay their electrical bills, which often results in a disconnection by the service provider (Blocker, 1985; Hernández, 2016; Jessel *et al.*, 2019). To avoid disconnection, low-income households resort to self-rationing of energy usage to a point where thermal comfort is compromised and potentially affects their health (ACOSS, 2013; Moore, Nicholls, *et al.*, 2017). Other households resort to what is known in the townships as "bridging" which is an illegal connection to the electrical grid, this is not only hazardous but also contributes to load shedding as the illegal connections overload the grid as they draw more energy than is provisioned for. The implementation of green building strategies aims to mitigate these challenges thereby improving the energy efficiency of low-cost units, and limiting the use of mechanical heating, ventilation and air conditioning (HVAC) which in turn will improve the health and financial well-being of households (Moore, Ridley, *et al.*, 2017).

- Green Building Council of South Africa (GBCSA) and rating system

Founded in 2007, the Green Building Council of South Africa is a member of the World Green Building Council. The core objective of the council is to transform the South African property industry through collaboration with the built-environment bodies, the state and practitioners in the research and development of green building solutions as well as building certification and training (GBCSA, 2019). Additional objectives include the establishment of a universal standard of green-building assessment, promoting the benefits of building green and, reducing the environmental impact caused by development (Hoffman, 2020). GBCSA developed the

Green Star SA rating tool which stipules what is considered a green building, the tool is used to rate the level of "green" in the different types of buildings (Sebake, 2009; Windapo, 2014).

- South African National Standards (SANS 10400-XA)

First added to the National Building Regulations (NBR) in 2011, the SANS 10400-XA is a single reference document that summarises SANS 204 standards which provides a basis for energy efficiency in buildings and ensures compliance with NBR requirements by practitioners. Topics covered in SANS 10400-XA include building orientation, efficient use of energy in HVAC applications where applicable and the heating of water through efficient means to ensure that the design of buildings considers energy efficiency and environmental sustainability (SANS, 2011).

1.2.4 Claimed benefits of green low-cost social housing

Ample literature exists that discusses the different benefits of sustainable housing, Harris and Krueger (2017) assert that the implementation of energy efficiency standards on low-cost housing has a direct impact on government expenditure on community health. Lan *et al.* (2014) concluded that room air temperature has a direct effect on occupants' sleep health, which according to Harris and Krueger (2017); Ishibashi and Shimura (2020) is directly linked to individuals' productivity and absenteeism in the workplace. Moore, Nicholls, *et al.* (2017) observed that occupants of green low-cost housing had improved health and well-being as there was a decrease in financial stress linked to high utility bills. Winkler *et al.* (2002); Harris and Krueger (2017) reached a similar conclusion that green building design promotes natural ventilation and efficient movement of air which prevents condensation of interior walls and the development of mould and spore that causes health problems. Smallwood (2015) suggests that occupants of green buildings can expect reduced operational costs. In contrast, some researchers conclude that limited evidence exists to confirm a positive relationship between green buildings and the satisfaction of their occupants (Paul and Taylor, 2008; Monfared and Sharples, 2011; Altomonte and Schiavon, 2013).

1.2.5 Environmental awareness

Ensuring sustainability is not only the function of the designers, financiers, and developers of green buildings, but it is also a function of the occupants of such buildings. It is not implausible to assume that the perceptions and attitudes about environmental awareness held by occupants of green buildings enable them to be conscious of the significance of their actions or lack thereof in working towards a sustainable future. The literature provides various definitions of environmental awareness; Chawla (1998) defines it as the need to obtain knowledge and have concern for the environment, and act to protect it. Nemcsicsné Zsóka (2008) asserts that environmental awareness is driven by ecological consciousness, attitudes, values, behaviour and a sense of obligation to act. Dunlap *et al.* (2000) state that it is an awareness of problems affecting the environment and the disposition to solve or contribute towards efforts to solve such problems. Kollmuss and Agyeman (2002) define it as the state at which the impact that human behaviour has on the environment is recognised. The key theme observed in the definitions presented by the authors is that awareness drives behaviour and action, however in the context of green building, McCunn and Gifford (2012) found that green building design in commercial buildings had little impact on the occupants' environmental awareness and attitude, this could have been as a result of a lack of information in green building and sustainability.

1.2.6 Measuring environmental perception and attitudes

Cole (1999) notes the possibility of occupants of green buildings not being fully informed about the green buildings they occupy and the impact such buildings have on the environment, the author refers to such individuals as “grey” occupants. It is not implausible to assume that in certain instances, occupants are grey not because of a lack of information but grey as a result of their perception and attitude towards sustainability. Hawcroft and Milfont (2010) note that forming a better understanding of the reason behind people’s actions towards the environment requires a measurement of their environmental attitudes (EA). Milfont and Duckitt (2010) define EA as the psychological propensity that is expressed by assessing the natural environment either favourably or negatively.

The above narrative has resulted in the following problem statement, research question and research proposition.

1.3 Problem statement

The study aimed to investigate the following problem:

Not much is known about the relationship between green low-cost social housing and the well-being of occupants as well as its impact on their environmental awareness.

1.4 Research question

The research question was:

What is the relationship between green low-cost social housing on the well-being of occupants and what impact does it have on their environmental awareness?

1.5 Research proposition

The research proposition to be tested was:

Green low-cost social housing developments have a positive effect on the well-being and environmental awareness of occupants.

1.6 Research aim

The aim of the research was:

To establish whether a relationship exists between green low-cost social housing and the well-being and environmental awareness of occupants.

1.7 Research objectives

The research objectives to addresses were:

i. Establish what constitutes green social housing.
ii. Determine what constitutes occupant well-being.
iii. Determine the perception of occupants on the impact of green features implemented in their buildings on their well-being.

iv. Establish whether occupying green buildings influences the environmental awareness of occupants.

1.8 Research methodology

The objectives of the research were achieved through the following steps:

i. An in-depth review of past and current literature on green building and low-cost housing.
ii. Data was collected through a qualitative approach, which comprised semi-structured interview questions.
iii. Multiple case study methodology – Thematic analysis was used to generate a comprehensive interpretation of the findings.
iv. Conclusions were drawn, and recommendations were presented.

1.9 Research limitations

i. A limited number of green-certified low-cost social housing developments exist in South Africa, thus limiting the study tospecific geographic locations.
ii. Well-being is subjective and is composed of various factors with varying levels of importance at an individual level and the literature does not provide consensus on an exemplary instrument to be used in measuring well-being Cooke *et al.* (2016).
iii. Only occupants of green-certified low-cost social housing were considered for interviews and thus limiting the sample size.

1.10 Report structure

Chapter one:

A brief introduction to provide context to the research area. An overview of the research topic along with the sub-topics will be discussed which will lead to the research problem, question, proposition, aim and objectives. The methodology approach will be discussed along with the identified limitations of the study.

Chapter two:

A critical review of literature on the research topic to expand on the overview contained in chapter one. The literature to be reviewed includes housing subsidies in South Africa, development sustainability and green building, low-cost housing and environmental awareness and the measurement thereof.

Chapter three:

The research methodology utilised in the study will be discussed and justified using literature from existing studies of similar nature.

Chapter four:

The research findings and the credibility of collected data will be discussed, and the presentation of the data analysis process outcome will address the question, aim and objectives of the research.

Chapter five:

The research proposition will be supported or refuted based on analysis from Chapter four, resulting in a conclusion to be drawn as to whether green low-cost social housing developments have a positive effect on the livelihood and environmental awareness of their occupants.

1.11 Conclusion

The proposal set out to validate the need for the research. This had been achieved through the provision of an overview of the concept of green building, and the presupposed benefits of green building as they relate to the livelihoods of occupants of low-cost social housing and their attitudes towards environmental sustainability.

Chapter 2: Literature review

2.1 Introduction

The objective of this chapter is to provide a critical analysis of the literature surrounding sustainable development, green building, occupant well-being and environmental awareness. The literature review format is represented by the flowchart in Figure 2.1

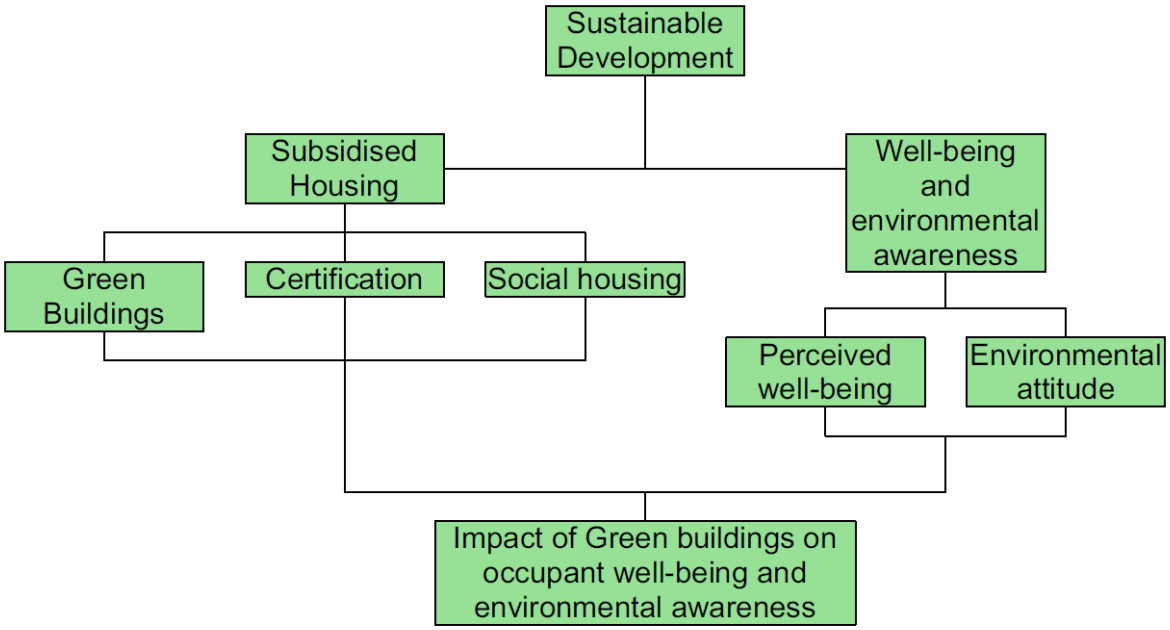

Figure 2.1 – Literature review flowchart

2.2 Subsidised housing in South Africa

The continuous rise in the population of South Africa coupled with the under-supply of housing that was inherited by the democratic government from the apartheid regime has resulted in rapid growth in the demand for government access subsidised housing programmes (Goebel, 2007b). The by-product of the housing demand increase has been a rise in greenhouse gasses (GHS) emissions as a result of producing the raw materials required for construction such as the manufacturing of reinforcement steel, plastic components, cement, and bricks as well as producing the energy which is used in completed homes (Tissington, 2011). According to Sowman and Urquhart (1998) approaches to housing previously employed in South Africa

were largely driven by political and economic agendas as opposed to an integrative delivery strategy that also considered sustainability and quality.

The development policy adopted in South Africa acknowledges the significance of sustainability however, the provision of state-subsidised housing in the country appears to promote architecture and settlement that is unsustainable (Goebel, 2007b), the development of housing opportunities for the poor is often located in peripheral land which in itself can breed other social ills such as increases in unemployment and continuous pressure being exerted to already struggling households due to raised transport costs to get to places of employment and economic hubs (Irurah and Boshoff, 2003). Du Plessis (2002) describes low-cost housing schemes as being no different from shacks with substandard thermal performance, constructed of expensive and environmentally taxing materials and technologies and having brief economic usability.

Globally there exists a consistent observation when dealing with housing for low-income households. In the United States, for example, Bullard (2018) and Chegut *et al.* (2016) make a similar observation to that of Du Plessis (2002), Goebel (2007a) as well as Irurah and Boshoff (2003) in that the provision of low-income housing is generally located in deficient areas that expose occupants to toxic air, water pollution, disproportionate energy costs, healthcare, transport and safety. Thus, in the context of the above challenges and to ensure sustainable development in the country, the government should prioritise the quality improvement of low-income housing and the associated living conditions of households.

2.2.1 Types of housing subsidies in South Africa

The South African National Development Plan (NDP) outlines various goals that it aims to achieve by the year 2030, chief among which is the transformation of human settlements through the improvement of the spatial economy to produce urban spaces that are vibrant and energetic, and the development of social housing has been identified as a critical component in achieving this objective (NPC, 2014). Tissington (2011); Mabin (2021) provide an overview of some forms of social housing schemes that are granted subsidies by the South African government. Fully subsidised housing is 40m^2 units that are built by the private sector on behalf of the government and provided to households earning less than R3500 monthly, these are

commonly known as RDP or BNG developments. Community Residential Units (CRU) are targeted at households with a combined income of less than R3500 per month, where the project is aimed at rehabilitating and upgrading hostels and buildings located in the inner cities, as the units are not for sale but are rented out to households (GroundUp, 2017). Subsidised rental housing targets citizens earning above R3500 but less than R7500 monthly. These units are distributed to the public through government-selected social housing institutions (Tissington, 2011). The Finance-Linked Individual Subsidy Programme (FLISP) which is administered by the National Housing Finance Corporation (NHFC) to enable access to affordable housing for low-income and middle-income households, where the subsidy targets households in the gap market that earn more than R3500 and as such do not qualify for full government subsidies but earn less than R22000, which is the minimum household income to qualify for a mortgage from private financial institutions. FLISP enables households in the gap market to access private finance through a once-off subsidy that can be used as a deposit towards paying off the loan (Lemanski, 2017). According to Dlamini and Yessoufou (2022), the position that social housing occupies within the construction industry presents an opportunity for the advancement of the sustainable development agenda through the implementation of environmentally conscious requirements into building specifications and materials.

2.2.2 Existing challenges in the subsidised provision of low-cost social housing

The provision of housing is a key component of development, as it impacts the social, economic, and physical construct of all communities (Tariq, 2011). However, the delivery of housing remains a challenge for many developing countries in Africa (Sokupa, 2009). In South Africa the housing conditions in which a large majority of the urban population live are indecent and the cost of average housing remains above the affordability range of the average South African (UN-Habitat, 2015). The premium asking price for average housing coupled with the ever-increasing population growth and low employment rates in the country has resulted in an intensification of government programmes to provide subsidised housing (Goebel, 2007b). However, the delivery of government-sponsored housing continues to be met with challenges ranging from corruption by government officials colluding with contractors, substandard design and material use, and lack of suitably located land for housing development (Manomano *et al.*, 2016).

2.3 Sustainable development

2.3.1 Definition and history

Sustainable development is the collocation of two significant terms, the first is sustainability which implies an ability to maintain an action, process or outcome over a prolonged period, or a state of continuous improvement of social, economic and ecological systems that are crucial to human development (Milne and Gray, 2013; Duran, Gogan, *et al.*, 2015). The second term is development, which is defined as a process aimed at improving the social quality of life and enabling growth in economic self-sufficiency (Kingsbury *et al*., 2004). Numerous definitions of sustainable development exist, the most popular of which is one coined by the Brundtland Commission Report (1987: 24), which defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". By this definition, advancements in economic and social development are to be maintained while protecting and ensuring environmental longevity. A similar definition is presented by Reyes (2001) where development is seen as a social condition in which rational and sustainable utilisation of natural resources satisfies the needs of a nation's population. Ben-Eli (2018) views sustainability as a fluid equipoise in the interface between society and the environment in which the development of such society realizes its full potential without creating permanent negative effects on the very environment on which it relies. Sustainable development advocates for the improvement of societal living conditions without endangering the ecosystems of the planet, it requires that resources be utilised in a manner that is conscious to ensure the long-term availability of said resources for others (Mohieldin, 2017). Kolk (2016) argues that sustainable development is achievable through the integration of environmental, economic, and social concerns in the processes of decision-making, to ensure balance in economic advancement, environmental permanence, and social well-being.

The concept of sustainable development is rooted in the discipline of economics and considers the capacity of the planet's limited natural resources to continuously support the needs of an ever-increasing human population (Dixon and Fallon, 1989; Pigou and Aslanbeigui, 2002). Klarin (2018) asserts that sustainable development is founded on three concepts; development, needs and future generations. The development concept encompasses socio-economic developments that are aligned to ecological limitations, the concept of the needs is concerned with meeting societal needs through equitable resource redistribution to ensure quality standards of living for all and, the concept of the future generation relates to the preservation and efficient use of natural resources to enable future generations to enjoy quality living

conditions. A similar definition is provided by Cosmulese (2019) in that sustainability as a concept is not only focused on the preservation of natural resources but also considers economic and social facets that are crucial to the advancement of society. Furthermore, the author suggests that the model of sustainability considers economic growth, environmental quality, population needs and quality of life, as well as recognising technological limitations. Taylor (2016) asserts that sustainable development is concerned with economic advancement, the protection of the environment and social parity. It can be deduced that sustainable development as a concept rest on three theoretical sustainability pillars, economic, social, and environmental sustainability, which constitute the triple bottom line framework (Klarin, 2018; Mensah, 2019).

Sustainable development is directly linked to the triple bottom line model which is a framework typically used in management accounting that considers three dimensions of performance, namely social, environmental, and economic (Slaper and Hall, 2011; Klarin, 2018). According to Norman and MacDonald (2004), the triple bottom line model seeks to identify trade-offs or equilibrium between the three sustainability pillars: (i) environmental sustainability: which is the responsibility to protect and preserve natural resources and the ecosystems that are crucial to the health and well-being of people (Morelli, 2011), (ii) social sustainability: focused on equitably securing the sociocultural needs and cultural identity of people (Popovic *et al.*, 2013; Klarin, 2018), and (iii) economic sustainability: which refers to actions that promote continuous economic development while considering social and environmental elements, economic sustainability directly linked to social and environmental sustainability and cannot be achieved if society continues to depend on the overexploitation of natural resources beyond limitations to drive development (Reddy and Thomson, 2014).

2.3.2 Objective and importance of sustainable development

A rise in the global population and demand for natural resources to fuel human development has resulted in compromised ecosystems, adverse climate change, and political and social instabilities in many parts of the world (Klarin, 2018). In the long term, continuing on the current trajectory will result in unfavourable living conditions for future generations, non-renewability of certain natural resources may affect production, and economic and technological advancements (Paxton, 1994; Mensah, 2019). Conscious of the impact that human development activities have on the earth and its future, much of the global community

has embraced and shifted to behaviour and actions favouring a reduction of adverse environmental impact through rational and efficient management of natural resources (Duran, Artene, *et al.*, 2015; Klarin, 2018). Sustainable development aims to determine and implement feasible approaches to integrating social, economic, and environmental dimensions of human development activities. According to Duran, Artene, *et al.* (2015), sustainable development provides a holistic consciousness of the relationship between the natural environment and societal needs to ensure development objectives are realised.

Cotter (1999) lists integration, public involvement, precautionary behaviour, generational equity, continuous improvement, and environmental integrity as the fundamental principles that society should be cognizant of in their effort and decision-making regarding sustainability.

Integration: According to Dernbach and Cheever (2015) the protection of the environment should be integrated into social and economic development decisions, and the viability of the economy along with social justice should be integrated into decisions concerning ecological quality. Cotter (1999) suggests a cross-functional, cross-discipline and cross-organisational collaboration approach where environmental, social, and economic issues are integrated into the decision-making process at all levels.

Public involvement: a transition toward a more sustainable future is not possible without public support and involvement (Cotter, 1999). Community involvement creates a sense of ownership and sustainability in development projects (Beyene, 2012). Kaufman and Alfonso (1997) further state that effective public participation results in individual and collective empowerment, economic development, and transformation in the socio-political landscape. Jerneck *et al.* (2011) call for a strengthening of discourse between science and the public to ensure that sustainability efforts respond to societal needs and values in conjunction with protecting the environment.

Precautionary behaviour: largely driven by the view that efforts to address environmental degradation and the depletion of natural resources are moving at a slow pace (Kriebel *et al.*, 2001), a precautionary approach requires that a lack of strong, incontrovertible scientific data to support or disprove a certain activity could result in adverse environmental consequences not be used as a reason to not implement measures to mitigate or eliminate the potential risk (Cotter, 1999).

Generational equity: adequate preservation of ecological integrity and natural resources to ensure a sensible quality of life in the present and the future (Cotter, 1999). According to Young

(1995), each generation is accountable for preserving and improving the environment to ensure that the next generation inherits a planet with favourable and uncompromised living conditions.

Continuous improvement: concern over the rate of ecological degradation and depletion of resources has required that the global community continuously seek and improve upon what is considered sustainable practices when executing their development activities (Cotter, 1999; Medne and Lapina, 2019)

Environmental integrity: the ability to enable and sustain an ecosystem that is both balanced and unified (Karr and Dudley, 1981). Environmental integrity results from the preservation and maintenance of the ecosystem and its life-support systems on which humanity is dependent for survival (Cotter, 1999), as a concept, environmental integrity considers the health of the environment in which natural communities that are sustainable, diverse, resilient and pure exist (Shathy and Reza, 2016).

Sustainability is a harmonious and selfless relationship between development activities by humans and the natural environment, one which places a high level of importance on working towards securing a quality life for future generations that is equal to or better than that of the present day through harmony between societal needs, economic development, and the environment (Brundtland Commission Report, 1987; Middleton and O'Keefe, 2001; Jordan, 2017). Ideally, the actions of society should advocate for development that signifies a sense of growth in human relationships with one another and the natural environment (Stead and Stead, 2000). According to Schmuck *et al.* (2003), solving environmental challenges and achieving sustainable development can only be realised once the rate at which the environment can recover and replenish itself is equal to or above the rate of negative environmental impact caused by human development activity. The author calls for a rethinking of the values that govern present-day social life and for an economy that is not fuelled by the consumption of natural resources but instead, seeks to improve the quality of life for all (Schmuck *et al.*, 2003). This is in line with the assertion of Oskamp (2000) that the placing of economic values as primary values for development has resulted in a disregard for the welfare and rights of other living beings present today and future generations that stand to inherit the planet.

2.3.3 Debates within sustainable development

As previously indicated, it is said that sustainable development is possible only through a harmonising of trade-offs between the three pillars of sustainability, economic, social, and

environmental sustainability (Klarin, 2018; Purvis *et al.*, 2019). However, achieving said balance presents a complex predicament in that pursuing sustainability requires that each pillar respect the sustainability interest of the next pillar to avoid an imbalance, the realisation of the sustainability potential of one pillar might rest on the unsustainability of the next, and this is often the case when dealing with economic growth and ecological sustainability (Mensah, 2019). Fundamentally, in countries with high levels of institutional quality and that practise efficient use of revenue generated from natural resources to advance development (Mehlum *et al.*, 2006), development is seen as resulting from a high level of consumption or over-exploitation of natural resources (Dingler, 2003; Ding and Field, 2004), development is the cause for the degradation of the environment and thus, cannot also be the solution to the problem it creates (Dingler, 2003).

Expansionists argue that man has achieved mastery over the natural environment and that development through economic expansion will breed technological advancements that will compensate for the depletion of natural resources (Rees, 2003), this is known as the perfect substitutability theory. It essentially suggests that the depletion of resources will cause a rise in the price of that particular resource and thus encourage the exploration of substitutes or the development of technologies that will result in more efficient ways to utilise said resource (Kopnina and Shoreman-Ouimet, 2015), as the growth of the economy will convert environmental capital into artificial capital and thus creating an increase in the flow of services stemming from the economy and a reduction in those from the environment (O'Neill, 2015). Dinda (2004) reaches a similar conclusion in that the resources necessary to realise sustainability can only be obtained through economic growth and that requires, at least at the present, the continued exploitation of natural resources. Meadowcroft (2000) presents an opposing view, which argues that while environmental conservation may be viewed as a limitation to development, environmental processes are fundamental to the development of humans, not only through their capacity to support life but also through the provision of natural resources on which economic development depends, therefore maintaining a high level of ecological preservation is crucial to ensuring the sustainability of development. This position is supported by IUCN (1980) in that development and environmental conservation are aligned. The report argues that the protection of the environment makes development possible. Morelli (2011) suggests that there exists a hierarchy of related values between the three pillars of sustainability, a productive environment provides resources that sustain societies, and it also provides a continuous flow of energy and raw materials that fuel economic development. The

author further suggests that the environmental pillar is the only one of the three pillars that - in the absence of interference from the other two – can exist entirely on its own and be self-sustaining. Therefore, human actions should be those which reflect an acknowledgement that environmental sustainability is an important foundation for achieving a sustainable socio-economic system and that it should be protected (Morelli, 2011).

2.4 Green building

2.4.1 Definition and history of green building

The concept of green building has its roots in the environmental movement that resulted from the energy crisis in the 1970s, a period that saw politicians, companies in the energy sector, environmentalists and the common man take a unified position in endorsing the need to devise solutions to combat environmental pollution and inefficient energy consumption (Mao *et al*., 2009). Interestingly the energy crisis in the 1970s was preceded by a period that favoured glass and steel-designed structures that were cooled and heated utilising energy-intensive HVAC units, but fossil fuels were in abundance and inexpensive and thus encouraged the development of inefficient buildings (Feltes, 2007). This is confirmed by Raiteri (2014) who observed that the design of structures reflected dematerialised and light systems that took no consideration to heat and cooling as that role were entrusted to plant design. According to Wellum (2020), in the United States, support for a move toward energy efficiency existed within two competing ideologies, one based on environmental concerns that advocated for environmental conservation to ensure a sustainable future and the other, a nationalist agenda looking to advance the economic and geopolitical power of the U.S through eradicating dependence on imported oil. Regardless of the conflicting agendas that existed, all parties encouraged critical research and activities toward reducing pollution to the environment and the improvement of energy efficiency (Zhang *et al.*, 2019) thus marking the age of sustainable building practices.

It is worth noting that although green building gained notable prominence post the energy crisis, the practice of green or sustainable design and construction is not novel, its roots can be traced as far back as the eighteenth century, a period that saw the commissioning of buildings such as Galleria Vittorio Emanuele in Milan and the Crystal Palace in the city of London. The buildings employed green practices by way of passive heating and cooling designs that made use of cooling chambers located underground and ventilators located on the roof (Federico Montella, 2008; Schoenefeldt, 2008).

In present-day construction, the need for sustainable approaches to design and construction has become undeniably apparent, environmental challenges such as climate change, pollution, erosion and deforestation continue to plague the planet and the built environment has been heavily criticised for its role in the excessive exploitation of natural resources and primary energy as well as the contamination produced by buildings which in turn has resulted in a negative impact on the environment, human health and economies (Korkmaz *et al.*, 2009; Doan *et al.*, 2017). Wallbaum and Buerkin (2003) also note that the construction sector is a key contributor to land dereliction, water and air pollution and producer of substantial waste. One of the primary materials used in construction is cement, the production of which releases an estimated ton of CO_2 into the atmosphere for every ton of cement produced (Djokoto *et al.*, 2014). A report by Architecture 2030 (2018) found that the building sector is responsible for an estimated 40 per cent of CO_2 emissions annually. This estimate indicates a considerable increase in CO_2 emissions over the last decade when considering that in 2007 the global estimate was 30 per cent (UNEP, 2007b).

The global community both in developed and developing countries has recognised the importance of working towards sustainable development and embracing green building practises as a key agent in the preservation of the environment and natural resources for a sustainable future (Korkmaz *et al.*, 2009). Gohardani (2014) argues that changes in architectural design, construction, and spatial planning concepts, combined with an approach that integrates the broad impact that a building has on human health, well-being and the environment are required to achieve sustainable development. To this end, green building has been put at the forefront as an effective instrument to ensure environmental, economic, and social sustainability in the built environment through its potential to reduce or eliminate negative impacts on the environment caused by construction activities (Hwang *et al.*, 2017).

Various definitions of green building exist in the literature, as the World Green Building Council (WGBC) (2019) defines it as the process of limiting adverse climate and environment throughout the entire lifecycle of a building. A similar definition is held by the United States Environmental Protection Agency (USEPA) (2016) which defines green building as an approach to construction that employs environmentally responsible and resource-efficient procedures throughout the lifecycle of a building. Ashuri and Durmus-pedini (2010) define it as the promotion of environmental, health and community well-being using materials, technologies and design techniques that are environmentally friendly. Green building promotes sustainable development through the efficient use of resources to satisfy present-day needs

without hindering the ability of future generations to do the same (Brundtland Commission Report, 1987). Green building is environmental preservation, awareness of the well-being of occupants in a building, considering both air quality and utilisation of space. It seeks to achieve harmony between the building, the environment and the improvement of life (Zhang *et al.*, 2019).

2.4.2 Contribution of green building toward environmental conservation

According to Wibowo (2003), the construction industry is pivotal to economic development however, its operations involving high energy and water consumption, natural resource exploitation and waste material production result in significant harm to the environment (Bowyer, 2007). Human activities in the pursuit of development, have a significant impact on the environment, however, in terms of complexity and enduring impacts on the ecosystem, the built environment remains unparalleled (Kibert, 2004). Construction industry processes pose a significant threat to the environment through the production of raw materials such as cement and steel, the solid waste produced during construction and the release of CO_2 into the biosphere and the ability of the earth to absorb such impact has its limits (Sev, 2009). The prevalence of increasing CO_2 emissions because of the construction industry is well documented (González and García Navarro, 2006; MacNaughton *et al.*, 2016; Architecture 2030, 2018). According to González and García Navarro (2006) construction environmental impact can be quantified in terms of the emissions generated as well as the energy expenditure. In terms of CO_2 emissions, the building sector is estimated to contribute directly or indirectly approximately 30 and 40 per cent of global CO_2 emissions (Goldemberg and Lucon, 2008; Darko, Chan, *et al.*, 2017; Architecture 2030, 2018). On the other hand authors such as Webb (2002); Edwards and Hyett (2005) proclaim that approximately half of the total energy expenditure of developed countries is a direct consequence of the construction sector or is closely linked.

According to Ametepey and Ansah (2014), the impact that buildings have on the environment is present throughout the entire life-cycle of the development, from site establishment, construction and operational phases through to the disposal of the building when it has reached its end of life. A similar observation is made by Usman and Gidado (2015) and Huovila (2007) in that building construction and post-construction activities degrade the environment through the generation of solid waste during construction phases and once completed, daily operation

by occupants generates CO_2 mostly through energy usage throughout the life of the building. The adverse impact that conventional building construction has on the environment has resulted in a consensus and commitment toward establishing strategies and actions to increase building sustainability (Akadiri *et al.*, 2012). The exploration of solutions to assist in reducing the over-exploitation of natural resources and greenhouse emissions in the effort to combat climate change has become of paramount importance around the globe (Huovila, 2007; Dakwale *et al.*, 2011). In support of advancing sustainable development in the built environment, construction companies continue to increase the integration of green practices into their plans and operations, the implementation of green innovations in the built environment is essential to achieving sustainability in the sector (Darko, Zhang, *et al.*, 2017; Wang *et al.*, 2018).

Dakwale *et al.* (2011) observe the existence of a chain reaction in green building practices, one which begins with improving the energy efficiency of a building, which results in a reduction in the buildings energy demand, the result of which a reduction in the harvesting of natural resources and the release of carbon emissions into the atmosphere. Kubba (2010) asserts that green building approaches as opposed to conventional building techniques are focused on minimum use of resources in the designing, erecting and operation of a building. Green buildings are efficient in their use of energy and resources and their construction and operation are considerate of the environment (GBCSA, 2010). Bowyer (2007) informs that green buildings address development challenges that have a direct impact on occupant health, such as efficient energy usage, water and waste management and air quality. Green building is environmental preservation, awareness of the well-being of occupants in a building, considering both air quality and utilisation of space. It seeks to achieve harmony between the building, the environment and the improvement of life (Zhang *et al.*, 2019).

2.4.3 Green building in a South African low-cost housing context

Like many developing countries, the South African construction industry holds significant economic and social importance through the creation of employment, and the provision of infrastructure to support other industries and contribute to the Gross Domestic Product (GDP) (Wibowo, 2003). Over the years the South African government has increased investments in the development of infrastructure as the sector has been identified as one that can assist the government in combating unemployment, bridging income disparity and realising sustainable

economic growth and development (Mosenogi, 2016). The industry is also influential in shaping the population's socioeconomics through the provision of housing, institutions of learning and hospitals (Ofori, 2012). However, the provision of sustainable low-cost housing remains a challenge for both developed and developing countries, yet it is most severe in developing countries such as South Africa (Ganiyu *et al.*, 2015). In developed countries such as the United States, low-income housing has historically been synonymous with low-quality indoor and outdoor spaces, air, and water pollution as well as poor waste management (Bailey *et al.*, 2017). Furthermore, Mulliner *et al*. (2016) note that the definition of affordable or low-income housing has exclusively based on a ratio that considers the cost of the house to the income of the household. The authors argue that such a definition disregards trade-offs such as transportation, health and education facilities amongst others that are crucial to the wellbeing and survival of low-income households, an argument can be made that the situation is even more severe in developing countries. Climate change and economic challenges have intensified global efforts to accelerate the adoption of green building for sustainable development and the reduction of poverty through efficient uses of energy, protection of ecosystems and preservation of natural resources (Brown and Southworth, 2008; Fisher *et al.*, 2012; Berardi, 2013).

Chester and Morris (2011) assert that high energy prices breed hardship for households that do not have adequate income or the ability to reduce their energy demand, the authors further state that in the United Kingdom households that spend above 10 per cent of their household income are deemed to be in what is termed fuel poverty. Research indicates that low-income households are severely impacted by continuously increasing energy costs, this is because their financial situation often results in the inability to pay their electrical bills, which often results in a disconnection by the service provider (Blocker, 1985; Hernández, 2016; Jessel *et al.*, 2019). To avoid disconnection, low-income households resort to self-rationing of energy usage to a point where thermal comfort is compromised and potentially affects their health (ACOSS, 2013; Moore, Nicholls, *et al.*, 2017). In South African townships, some households resort to what is known in the townships as "*izinyoka*" which is an illegal connection to the electrical grid, this is not only hazardous but also contributes to load shedding as the illegal connections overload the grid as they draw more energy than is provisioned for (Mujere, 2020).

In South Africa, challenges such as water shortages, consistent load-shedding and extreme weather temperatures have put pressure on the building sector to adopt and implement green building practices (Simpeh, 2018b). This is because developing countries consume natural

resources and energy at an intensive rate, these processes greatly contribute to land, water and air pollution (Oguntona, 2019). It is in the context of these challenges that there exists pressure from political, social and environmental movements to lessen the waste and CO_2 generated during low-income housing construction, in response, the housing sector in South Africa has steadily embraced the move towards using green practices and alternative building technologies (ABT) in delivering affording low-income housing (Ganiyu *et al.*, 2015). South Africa recognises the importance of sustainability, this has led to the formation of institutions such as the Green Building Council of South Africa (GBCSA) and the implementation of standards such as SANS 10400-XA and SANS 204 that aim to guide industry practitioners in matters of energy efficiency and sustainability in the design of buildings, this is especially crucial in low-income housing.

The requirement for green building has shifted from being a choice of convenience and luxury and has evolved into an obligation to a global society that is increasingly growing environmentally conscious (Ashuri and Durmus-pedini, 2010). The implementation of green building strategies aims to mitigate these challenges thereby improving the energy efficiency of low-cost units, and limiting the use of mechanical heating, ventilation and air conditioning (HVAC) which in turn will improve the health and financial well-being of households (Moore, Ridley, *et al.*, 2017). Sustainable housing is designed, constructed and operated in a manner that reflects environmental concern, consideration for economic development and quality of life for the end-user, further, sustainable housing aims to address social challenges such as poverty, public health, inadequate access to water and electricity as well as the uncertainties related to the economy (Golubchikov and Badyina, 2012).

- Green Building Council of South Africa (GBCSA) and Green Star SA

Founded in 2007, the Green Building Council of South Africa is a member of the World Green Building Council. The core objective of the council is to transform the South African property industry through collaboration with the built-environment bodies, the state and practitioners in the research and development of green building solutions as well as building certification and training (GBCSA, 2019). Additional objectives include the establishment of a universal standard of green-building assessment, promoting the benefits of building green and, reducing the environmental impact caused by development (Hoffman, 2020). GBCSA developed the Green Star SA rating tool which stipules what is considered a green building, the tool is used

to rate the level of "green" in the different types of buildings (Sebake, 2009; Windapo, 2014). The Green Star SA rating tool enables public and private buildings to be given a rating in 10 (ten) different categories, thereby allowing GBCSA to acknowledge and reward practitioners and organisations in the built environment for their environmental leadership (Saad, 2016). According to the GBCSA (2017), categories considered include the following.

(1) Management: the use of environmental principles throughout the different project phases. (2) Indoor Environment Quality (IEQ): considers thermal comfort, ventilation and lighting which all contribute to occupant well-being. (3) Energy: analyses reduction in energy and greenhouse gas emissions linked to the production of energy. (4) Transport: focuses on reducing automotive commute in favour of alternative transport. (5) Water: rates the efficiency of rainwater harvesting and reuse systems in reducing potable water usage. (6) Materials: considers material selection and use to reduce exploitation of natural resources and encourage recycling and reusability. (7) Land use and ecology: rates the level of impact a building has on ecological and biodiversity systems. (8) Emissions: considers the impact a development has on the environment through the emissions generated or the waste produced by site operations. (9) Innovation: focused on technological innovation, design and practices that influence a building's environmental performance. (10) Socioeconomic: encourages the development and improvement of socio-economic conditions around a development project. Development projects are awarded a 4-, 5- or 6-star rating. Where a 4-star rating signifies the utilisation of industry best practices in the development, a 5-star rating distinguishes excellence at a national level and a 6-star rating indicates an international level of excellence (Saad, 2016).

- South African National Standards (SANS 10400-XA)

First added to the National Building Regulations (NBR) in 2011, the SANS 10400-XA is a single reference document that summarises SANS 204 standards which provides a basis for energy efficiency in buildings and ensures compliance with NBR requirements by practitioners. Topics covered in SANS 10400-XA include building orientation, efficient use of energy in HVAC applications where applicable and the heating of water through efficient means to ensure that the design of buildings considers energy efficiency and environmental sustainability (SANS, 2011).

2.4.4 Challenges to the implementation of green building in South Africa

Although dubbed as one of the world's fastest-growing green building markets and with professional and technological growth potential (Jones and Mandyck, 2016), South Africa still maintains a small percentage of green buildings in the housing stock and that green building holds a significantly minute share of the South African building industry (Simpeh *et al.*, 2021). It is evident that while green building practices are gradually gaining momentum, the large-scale adoption and implementation of green building practices remain challenging. Joubert and Cloete (2012) point to socio-economic disparity and the perceived high costs of green technologies as chief constraints to the adoption of green building. Additionally, Hoffman and Henn (2008) argue that psychological and social uncertainties are a greater barrier to the adoption of green building than technological and financial factors. Marsh *et al.* (2020) identified limited knowledge about green building, fear of embracing new construction technologies and processes, inadequate legislation, and government support as well as the limited availability of suppliers of green products and technologies as barriers to the adoption of green building. Similarly, Nordin *et al.* (2017) argue that while the cost aspect acts as a significant barrier to green building adoption, other factors include limited green building knowledge and awareness, low demand for green homes, and limited legislation to enforce green building practices. Yee *et al.* (2020) concluded that the adoption of green building is hindered by high initial expenses, limited industry expertise in green building and collaboration between stakeholders and suppliers. Dwaikat and Ali (2016) reported that the approximate cost of a green building is between 1 and 25 per cent more than that of a conventional building, owing to the cost difference to the presumed design complexity and modelling associated with utilising green practices (Wu and Low, 2010). A comparable conclusion is drawn by Wu *et al.* (2019) who argue that the delivery of green buildings may be of a complex nature and utilise intricate technologies and procedures. Furthermore, O'Neill (2002) reported a 3 to 4 per cent increase in material costs when utilising green materials as opposed to conventional building materials. In South Africa, Zenios and Allen (2016) identify concerns over the upfront project costs and scarce green-building know-how and experience by consultants and contractors as the main impediments to the adoption of green building. Similarly, Jacobs (2011) argues that the major impediments to the adoption of green building are limited information on green building practices and the environmental consequences of continuing the use of non-sustainable methods.

From the literature, the barriers to the implementation of green building practices can be summarised into four groups, namely financial considerations, legislation, knowledge, and awareness. For addressing the financial barriers, Akomea-Frimpong *et al.* (2022) point to models such as green finance to assist in funding the advancement of green building, the model integrates environmental conservation and social justice with monetary returns from green building. According to Volz (2018), green finance provides favourable credit terms for projects and products concerned with sustainability, and access to funding for both public and private investors is an important driver for supporting green buildings (Zhang *et al.*, 2019). Further, CEObriefing (2010) notes the importance of financial institutions in supporting green property development through various mechanisms and being a catalyst for the transition to sustainable buildings. The legislative impediment requires that government become more involved in supporting the advancement of green building through the adoption of policies that promote sustainability in the built environment and provide incentives to encourage practitioners and developers to adopt green building. According to Joubert and Cloete (2012), the South African government acknowledges the role that green building plays in the transformation of the country's economy and has implemented interventions such as amending the NBR to include standards relating to energy efficiency as a show of commitment to achieving a greener built environment. Additionally, Saka *et al.* (2021) argue that government can promote green building by incentivising stakeholders involved in green development projects. Financial incentives can be grouped into four categories, loans, grants, tax and rebates which are critical in promoting green building and reducing national resource wastage (Rana *et al.*, 2021). For example, the Section 12L tax incentive by the South African government allows businesses to receive 95 cents per kilowatt-hour (kWh) tax deduction on energy consumption which results in savings in energy expenditure estimated at 30 per cent (GBCSA, 2019). Lastly, to address the knowledge and awareness challenge, Simpeh (2018a) argues that indistinct and disjointed information relating to green building negatively affects people's willingness to embrace and adopt green building practices, similarly, Hoffman and Cowie (2014) call for increased availability of accurate and reliable information on current industry trends to assist decision-makers in the green building sector. Additionally, Cole (2019) suggests that advancements in green building require that more emphasis be placed on educating the public about sustainability as it relates to buildings, as the author calls for an educational framework that simplifies complex green building topics into understandable concepts and thus equips the general public with knowledge and skill to take action.

2.5 Claimed benefits of green building in the context of social housing

Modern human beings spend a significant amount of their lives indoors, whether it be at work or home. Thus, together with the need for energy efficiency, the buildings that humans occupy should be designed and operated in a manner which continuously seeks to fulfil the intricate requirements of comfort, safety, satisfaction, and well-being of occupants (Klepeis *et al.*, 2001; Donn *et al.*, 2012).

Buildings consume a considerable amount of energy, this process takes place from the inception of the building project, during its operational phase through to its final demolition (Schimschar *et al.*, 2011). The energy consumption of a building during the various stages has a significant impact on the production of greenhouse gases released into the atmosphere (Lenzen and Treloar, 2002). Improved energy efficiency and the use of renewable energy sources in buildings greatly contribute to reducing the adverse impact that energy consumption by the building sector has on the environment (Lee and Chen, 2008). The literature has no shortage of authors that advocate for green building and the benefits associated with the practice (Bowyer, 2007; Ashuri and Durmus-pedini, 2010; Golubchikov and Badyina, 2012; Zhang *et al.*, 2019).

Green buildings are said to have a water and energy demand that is between 30 per cent and 50 per cent less than that of conventional buildings (Kats, 2003; Yudelson, 2010). Smallwood (2015) suggests that occupants of green buildings can expect reduced operational costs. A similar conclusion is reached by Shabrin and Kashem (2017) who argue that the operating costs linked to low energy and water consumption result in an earlier return on investment, they further argue that green buildings hold a higher market value that enables developers and owners to charge premium rates. Miller *et al.* (2008) also conclude that green building owners can expect to sell their buildings for an estimated 10 per cent more per square foot ($0.09m^2$) than conventional buildings. An argument can be made that a reduction in energy spending by households may assist in reducing instances of illegal connections to the electrical grid as households would be in better financial positions, the result would be a potential reduction in load shedding as Eskom has stated that the overload on the system as a result of illegal connection contributes to load shedding (Mujere, 2020). An example of the benefits of green initiatives is the Kuyasa project in Cape Town, although the project did not employ the full spectrum of green practices, it made use of green retrofits that included low-energy lighting systems, thermal insulation, and solar geysers. According to a report by the WHO (2011), the

retrofits implemented by the project have resulted in a reduction in household energy and water spending.

Green buildings are said to have a positive impact on the mental and physical health of occupants. Zigenfus (2008) notes that this positive impact is accomplished through the incorporation of environmentally friendly materials and operational elements. A comparable observation is made by Hoffman (2020) in that green buildings aim to minimise the impact that the built environment has on the well-being of occupants and the environment through efficient use of power and water, waste and pollution reduction and environmental ruin. According to Allen *et al.* (2015), green buildings improve occupant well-being by providing improved indoor air quality (IAQ) which has been proven to reduce asthma and allergies. Ghodrati *et al.* (2012) posit that green buildings are not only environmentally considerate but also provide improved indoor environment quality which positively impacts the health of occupants. A comparable observation is made by Fisk and Rosenfeld (1997) who suggest that improved air quality significantly reduces illnesses associated with respiratory diseases, allergies and asthma, the authors further concluded that the financial benefits of improving the quality of indoor environments far outweighed the cost.

Harris and Krueger (2017) assert that the implementation of energy efficiency standards on low-cost housing has a direct impact on government expenditure on community health. Harrington *et al.* (2005) assert that energy poverty resulting from high energy prices has the potential to cause mental health problems because of stress linked to financial concerns. Hills (2011) suggests that a connection exists between energy poverty, debt and poor mental health. Lan *et al.* (2014) concluded that room air temperature has a direct effect on occupants' sleep health, which according to Harris and Krueger (2017); Ishibashi and Shimura (2020) is directly linked to individuals' productivity and absenteeism in the workplace. Moore, Nicholls, *et al.* (2017) observed that occupants of green low-cost housing had improved health and well-being as there was a decrease in financial stress linked to high utility bills. Winkler *et al.* (2002); Harris and Krueger (2017) reached a similar conclusion that green building design promotes natural ventilation and efficient movement of air which prevents condensation of interior walls and the development of mould and spore that causes health problems. On the Kuyasa project, the WHO (2011) reported that the installation of insulation not only improved the thermal comfort of the units but also reduced dampness and condensation on the walls and ceilings and thus reducing the risk of diseases. Solar geysers enabled affordable and safe access to hot water, which the WHO (2011) argues has a significant impact on hygiene and thus, health. This is

supported by the findings of Best and Burke (2019) who observed that occupants of homes that lacked insulation had challenges in maintaining adequate thermal comfort and that possibility of being unable to settle energy accounts doubled for households that lacked access to solar geysers. In addition to energy and thermal comfort, Wilkins *et al.* (1989) and Ticleanu (2021) found that lighting quality also affects human health through its potential to induce headaches. Furthermore, access to daylight and window views positively impacts the well-being and psychological functioning of occupants in a building (Ne'Eman, 1974; Boyce *et al.*, 2003). In summary, the literature paints a picture that portrays a relationship between green buildings, occupant finances, health, and overall well-being.

2.6 Environmental awareness and attitudes of green building occupants

Ensuring sustainability is not only the function of the designers, financiers, and developers of green buildings, but it is also a function of the occupants of such buildings. It is not implausible to assume that the perceptions and attitudes about environmental awareness held by occupants of green buildings enable them to be conscious of the significance of their actions or lack thereof in working towards a sustainable future. The literature provides various definitions of environmental awareness; Chawla (1998) defines it as the need to obtain knowledge and have concern for the environment, and act to protect it. Nemcsicsné Zsóka (2008) asserts that environmental awareness is driven by ecological consciousness, attitudes, values, behaviour and a sense of obligation to act. Dunlap *et al.* (2000) state that it is an awareness of problems affecting the environment and the disposition to solve or contribute towards efforts to solve such problems. Kollmuss and Agyeman (2002) define it as the state at which the impact that human behaviour has on the environment is recognized. The key theme observed in the definitions presented by the authors is that awareness drives behaviour and action, however in the context of green building, McCunn and Gifford (2012) found that green building design in commercial buildings had little impact on the occupants' environmental awareness and attitude, this could have been as a result of a lack of information in green building and sustainability. Cole (1999) notes the possibility of occupants of green buildings not being fully informed about the green buildings they occupy and the impact such buildings have on the environment, the author refers to such individuals as “grey” occupants. It is not implausible to assume that in certain instances, occupants are grey not because of a lack of information but grey as a result of their perception and attitude towards sustainability. Hawcroft and Milfont (2010) note that

forming a better understanding of the reason behind people's actions towards the environment requires a measurement of their environmental attitudes (EA). Milfont and Duckitt (2010) define environmental attitude as the psychological propensity that is expressed by assessing the natural environment either favourably or negatively.

2.7 Well-being

According to Pearce (2003), good design positively influences physical and psychological health, which creates a sense of identity and well-being, facilitates positive social relationships, increases productivity and reduces crime. The concept of well-being is often used interchangeably with quality of life, happiness and subjective well-being (Ryan and Deci, 2001; Camfield and Skevington, 2008). Bergdolt (2008) and McMahon (2006) suggest that well-being is aligned with good health and happiness, both of which are subjective and are determined by individuals. Similarly, McDowell (2010) defines well-being as contentment or satisfaction resulting from optimal functioning, and that it is both subjective and relative.

2.7.1 Physiological and psychological well-being

The distinction between survival needs and well-being needs by author Boyden (1971) provides a great opportunity for establishing the relationship between well-being and the built environment, more specifically green buildings. Boyden (1971) reasons that survival needs are environmental aspects that have a direct impact on human health, such as clean water and air, the absence of pathogens and contaminants and the prospect of rest. Moreover, well-being needs are characterised as having an indirect impact on human health but can influence overall health through their connection to perceived quality of life, contentment and psychological health (Boyden, 1971).

An argument can be made that the built environment and the manner in which individuals interact and experience it can influence both survival and well-being needs. Similarly, Orians and Heerwagen (1992), Kaplan and Kaplan (1989) and Kellert and Wilson (1993) suggest that a built environment that encompasses features of preferred natural settings is conducive to human well-being and functioning. Therefore, a direct correlation exists between well-being and nature, and creating conditions that are conducive to well-being requires that human habitats encompass natural features. Heerwagen (2000) posits that habitat selection is directly

linked to the behaviour, survival and well-being of the organisms that occupy that habitat and that it is no different for humans. Studies by Ulrich (1993) and Ulrich (1984) found that providing access to the natural environment through windows promoted stress reduction and health. Similarly, Kaplan and Kaplan (1989) concluded that natural views through windows reduced frustration, increased life satisfaction and improved health. Furthermore, buildings have a direct impact on the sleep health of occupants through improved thermal comfort and indoor air quality (IAQ) (Wargocki *et al.*, 2018). The United States Environmental Protection Agency (2016) defines IAQ as the quality of air inside buildings and structures, particularly as it relates the comfort and health of the occupants. A study conducted by Liao *et al.* (2019) found that a positive relationship exists between IAQ and sleep, the study revealed that sleep quality was improved by increasing IAQ. The importance and benefits of sleep to human health are well documented in the literature, poor sleep or sleep deprivation has a significantly negative impact on human health and well-being (Chow, 2020). Research indicates that inadequate and poor sleep quality may result in increased susceptibility to depression, obesity and cardiovascular illnesses among other health risks (Cappuccio *et al.*, 2008; Cappuccio *et al.*, 2011; Zhai *et al.*, 2015)

2.7.2 Financial well-being

Praag (2003) suggests that well-being is a result of a person's satisfaction in several areas, these include finance, home, health and environment. Joo (1998) observed that well-being included an individual's perception of their financial status, living conditions and their ability to meet their needs. In both definitions, it is apparent that finances contribute greatly to a person's overall well-being. The Consumer Financial Protection Bureau (2017) defines financial well-being as a state in which a person can meet their current and continuing financial obligations, is secure in their financial prospects and can make choices that enable them to enjoy life. Similarly, Aldana and Liljenquist (1998) note that financial stress is independent of income, they argue that financial stress results from one's inability to meet economic responsibilities and not how much one earns. According to Goldsmith (2022) having financial well-being offers individuals or families protection against social ills such as ill health and poverty. Financial well-being can be affected by financial stressor events, which Kim *et al.* (2003) describe as being non-normative financial events that cause financial stress and decrease financial well-being. An accumulation of stressor events results in susceptibility to psychological problems, physical ailments and behavioural disorders (McGuigan, 1999).

Bagwell (2000) makes a comparable observation, the author suggests that the absence of financial well-being may result in social, physical and emotional stress. Furthermore, a study by Drentea and Lavrakas (2000) revealed that individuals suffering from financial stress presented increased levels of physical impairment and deteriorating health. Pearlin *et al.* (1981) found that a positive relationship exists between financial stress and anxiety, which according to Chow (2020) are significant sources of sleeping difficulties.

2.8 Chapter Summary

This chapter presented a critical analysis of the available literature covering sustainable development, green buildings, and occupant well-being and the impact green buildings have on the environmental perception of occupants. The literature review revealed both developed and developing countries recognised the importance of working towards sustainable development and embracing green building practices as a key agent in the preservation of the environment and natural resources. Additionally, the literature seems to suggest that green buildings have the potential to address development challenges that have a direct impact on occupant health, such as efficient energy usage, water and waste management, and air quality. However, while the importance and need for sustainable development are widely accepted, some of the challenges in the implementation of green sustainable development were found to be socio-economic disparity, psychological and social uncertainties as well as the perceived high costs of green technologies. The literature also revealed debates within the subject of sustainable development with some arguing that harmonising trade-offs between sustainability, economic, social, and environmental sustainability pillars present a complex predicament in that pursuing sustainability requires that each pillar respect the sustainability interest of the next pillar to avoid an imbalance, the realisation of the sustainability potential of one pillar might rest on the unsustainability of the next. Furthermore, subscribers of the perfect substitutability theory argue that development through economic expansion will breed technological advancements that will compensate for the depletion of natural resources. Lastly, the literature revealed a connection between the built environment and overall human well-being by discussing factors that contribute to overall well-being, such as physical and psychological health, sleep quality and financial well-being and how these are connected and may be influenced by the built environment.

Chapter 3: Research Methodology

3.1 Introduction

This chapter presents an outline of the complete research process employed in achieving the aim and objectives of the research. The main sections of the different stages of the research methodology follow a logical and sequential approach consisting of a detailed description of the research design that was selected for the study and the justification thereof. The researcher then presents an overview of the research philosophy that informed the research strategy used in the study. The proceeding section describes the research method and discusses how the reliability and validity of the research were safeguarded. This is followed by a discussion on the unit of analysis as well as the sampling strategy that was employed in the study. The last section of this chapter describes and justifies the data collection approach, the data analysis instruments that were used and the procedures that were followed to conduct the study.

3.2 Research design

The framework of research methodologies and procedures a researcher selects to carry out a study is known as the research design. It enables researchers to focus on developing research techniques appropriate for the topic being researched and to ensure that the objective of answering the research questions is achieved. Research design provides a blueprint of specifications for the various processes and strategies that need to be followed to ensure high-value answers to research questions are gained or that the set of objectives of the study is achieved with optimal control of variables (Hassan, 1995). Similarly, Kerlinger (1986) defines research design as a plan, structure and strategy of investigation that enables researchers to answer research questions while having a high degree of control over variables. Furthermore, Creswell and Creswell (2017), assert that the research design lays out the strategy for linking the theoretical research questions to relevant and practical research.

This section of the research methodology chapter discusses the comprehensive approach selected and utilised to logically integrate the various components of the research to effectively meet the research objectives and address the research question (De Vaus, 2001; Trochim and Donnelly, 2001). Additionally, the section establishes the decision-making processes and justification thereof, theoretical investigation structure, and data collection and analysis techniques employed to address the research question.

3.2.1 Research philosophy

Research philosophy concerns the choice of research strategy and how data about a specific phenomenon should be collected, interpreted, and utilised (Žukauskas *et al.*, 2018). Similarly, Ryan (2018) asserts that research philosophy shapes the framework that guides the design of data collection and analysis strategies employed in developing and understanding knowledge. According to Holden and Lynch (2004), knowledge development and interpretation depend on certain assumptions rooted in the researchers' perspective of the world. Thus, research philosophy is primarily influenced by what the researcher considers fact, reality, and knowledge (Ryan, 2018). According to Saunders *et al.* (2007), research philosophy may be categorised into four main types of philosophies, namely (i) Pragmatism, (ii) Positivism, (iii) Realism, and (iv) Interpretivism.

Pragmatism is a factually based philosophy that argues that ideas are relevant only where they encourage action (Kelemen and Rumens, 2008; Žukauskas *et al.*, 2018). The philosophy attempts to integrate subjectivism and objectivism, realities and values, rigorous and precise knowledge, and various studied experiences by considering concepts and theories as mediums of thought and action instead of abstract forms (Saunders *et al.*, 2009). Researchers are not limited to a specific set of rules when deciding on a research approach; instead, pragmatism allows researchers the freedom to elect whichever methods and procedures best serve their research needs and aims (Alghamdi and Li, 2013).

Positivism argues that reality can be understood objectively and that the researcher disassociates themselves from any personal ideals and instead takes the form of an objective analyst that works independently of any beliefs they may hold (Žukauskas *et al.*, 2018). Positivism is aligned with scientific models rooted in verifying assumed deductions from the findings of previous studies and is established before the commencement of new research (Park *et al.*, 2020). Research that follows a positivist approach generally seeks to identify descriptive undertones or casual associations using quantitative methods (Park *et al.*, 2020).

Realism is rooted in the idea that reality is not the construct of the human mind but is independent. The philosophy assumes the use of scientific approaches to developing knowledge (Saunders *et al.*, 2009). The realism philosophy exists in two parts: direct realism and critical realism. Where direct realism argues that the world exists precisely as portrayed through a person's senses, critical realism argues that while people can experience the images

and sensations of reality, such sensations and images are not a true reflection of reality and are deceptive (Saunders *et al.*, 2009; Novikov and Novikov, 2013).

Interpretivism is based on the idea that the social world can be understood subjectively; it prioritises the understanding of people's experiences of reality and argues that the researcher is not independent of the research but plays a pivotal role through observation of and interaction with the research subject and lastly, that the research approach is dependent on the interests of the researcher (Žukauskas *et al.*, 2018). The philosophy argues that people are different from physical phenomena in that people create meanings influenced by their backgrounds, circumstances, and experiences. Therefore, they cannot be studied in the same manner as physical phenomena as different people experience social realities differently (Crotty, 1998).

3.2.2 Justification of research philosophy choice

This study employs an interpretivism research philosophy which recognises that social constructions such as language, instruments, shared meanings, and consciousness provide access to reality (Myers, 2008). The research adopts a qualitative data collection method that draws on primary data derived from semi-structured interviews that aim to understand the lived experiences of people occupying green-rated social housing and whether their well-being and attitudes towards environmental conservation have been impacted. An interpretive approach allows the researcher to understand lived experiences by concentrating on how people describe their feelings and relationship with reality. As previously indicated, there are limited studies that assess the relationship between green buildings and the well-being and environmental attitudes of occupants, and interpretivism is ideal for constructing theory in areas with insufficient or nonexistent priori theory.

3.2.3 Research method

The selection of a research method to be utilised in any study is of critical importance as it directly affects the theoretical framework, sampling, data collection and analysis, and interpretation of findings and can affect the validity and reliability of results (Bilgin, 2017). Asenahabi (2019) notes that the research method determines the data types, the methods of collection and analysis, and how to use the produced data to answer the research question. Similarly, Jongbo (2014) asserts that data collection without considering the most appropriate

research method to answer the research question is likely to draw feeble conclusions and fail to meet the research objective. Research methods are divided into two categories: qualitative and quantitative, with the researcher basing the choice of research method to employ on the type of research being conducted Queirós *et al.* (2017); (Asenahabi, 2019). Equally, Borrego *et al.* (2009) advocate for research questions being the main driver behind research method selection.

Kothari (2004) defines quantitative research design as a method or technique used to produce quantifiable values. Quantitative research is social research that utilises empirical methods and statements and explains phenomena through analysing and interpreting collected data using statistics (Cohen and Manion, 1980; Aliaga and Gunderson, 2002; Creswell and Creswell, 2017). Quantitative research is focused on objectivity and most appropriate approach when it is possible to collect quantifiable measures of variables and assumptions from population samples (Queirós *et al.*, 2017). According to Holton and Burnett (2005), qualitative research methods are most useful when studying large sample groups and applying the conclusions reached to make generalisations to broader groups outside the sample being studied. Similarly, Bridgmon and Martin (2012) assert that sample sizes in quantitative research are generally large and are considered to be a general representation of the population group being studied, the results are interpreted as being an acceptable and adequately exhaustive view of the entire population. In summary, quantitative research requires that phenomena be reduced to values in numerical format to conduct statistical analysis (Apuke, 2017). It places emphasis on proof as opposed to discovery, and is less suitable for studies that aim to understand human emotion and behaviour, and thus requires large sample sizes to produce reliable statistical analysis (Vasileiou *et al.*, 2018; Leedy and Ormrod, 2019).

For this research, a qualitative research method was chosen, and the following section presents a detailed discussion of qualitative research methodology and provides the justification for the use thereof.

Adding to the definitions already presented, Busetto *et al.* (2020) defines qualitative research as the study of the nature of phenomena and is used in addressing questions relating to reasons why something is or is not observed, evaluating complex multidimensional interventions, and improving interventions. In contrast to quantitative research which relies upon natural science methods to generate numerical data and draw conclusions, qualitative research focuses on words and applies various systems of enquiry to study human phenomena including historical

analysis, ethnography, grounded theory, case study, phenomenology and biography (Punch, 2013; Ahmad *et al.*, 2019). Qualitative research is concerned with the "why" as opposed to the "what" of social phenomena and is reliant on the lived experiences of people to create meaning in the world around them (Ahmad *et al.*, 2019).

It has been argued that results from qualitative studies are often accompanied by a caution of being preliminary and thus implying that qualitative approaches should be implemented to verify and validate the findings (Kirkman, 2002). Additionally, the authenticity of qualitative research receives criticism from scholars and quantitative researchers alike due to how differently the concepts of validity and reliability are addressed in the two research methods (Shenton, 2004; Ritchie *et al.*, 2013). However, Polkinghorne (1988) contends that narrative research operates in an environment that is unrestricted by formal systems and is achieved by emphasising the retention of the dialectal reality of human existence and is therefore more thorough. This means that participants in qualitative research can freely express their thoughts and opinions without having to conform to pre-set constraints to generate specific answers; consequently, the authenticity of answers to questions is thought to be high. This is in line with the findings of Denzin (2001) who asserts that qualitative research approaches generate rich, detailed descriptions of respondents' thoughts, feelings and how that drives their actions.

3.2.4 Qualitative Case Study

Baxter and Jack (2008) define a qualitative case study as a research methodology that is used in the study of a phenomenon within a given context using various data sources, case studies allow the researcher to study a phenomenon from various perspectives and thereby exposing the different layers from which the phenomenon is composed. Mouton (2001) describes a case study as a research strategy that employs the use of qualitative research methods to define and assess the performance of phenomena in their natural environment and favours the implementation process over quantifiable results. Tellis (1997) notes that qualitative case studies allow the researcher to achieve a deeper understanding and holistic perspective of the research problem. Alam (2020) reaches a similar conclusion in that the case study research method can investigate and illustrate the research topic in various ways through the collection of data within the set context of the subject matter and thereby assisting the researcher in better understanding the issues being researched and to study the data more descriptively.

According to McMillan and Schumacher (1984), people's actions, thoughts and feelings are directed by their perception of what is real to them. Therefore, this research aimed to explore the thoughts and feelings of occupants of South African social housing developments with green features concerning their well-being by employing a qualitative case study approach that would make use of semi-structured interviews as an agent for data collection (Baxter and Jack, 2008; Ahmad *et al.*, 2019). Fridlund (1997) states that the case study methodology is widely accepted and preferred when conducting research that aims to answer questions of *"why"* or *"how".* As such, a case study approach was selected for this study to understand how living in a green building affects the well-being of the occupants and how their attitude towards the environment is affected or influenced. It has been found that a case study research approach offers some benefits in that (i) the examination of data generally focuses on the environment in which the functions are executed, and (ii) the nature of case study research makes it possible for researchers to employ qualitative and quantitative methods to analyse collected data and lastly, (iii) qualitative case studies enable the researcher to obtain a holistic description of the everyday life situation and difficulties of the subject being studied (Yin, 2009; Zainal, 2017; Alam, 2020). This is in line with the definition provided by Gephart Jr (2004) which states that a case study is a single unit or event of analysis that the researcher selects and uses varying sources of data which can be analysed both qualitatively and quantitatively. Queirós *et al.* (2017) suggested that case studies are useful in the advancement of the knowledge base of any field of study, they are an enabler of innovation and offer an opportunity to challenge prevailing theoretical assumptions.

3.2.5 Multiple Case Study

This study made use of a multiple-case study approach to generate rich descriptions of the relationship between green buildings and occupant wellbeing. This is in line with the writings of Lincoln and Guba (1985) that suggest that using multiple data sources allows the researcher to access a richer pool of data and legitimises the research findings. Stake (2013) defines a multiple case study as a distinct endeavour to study something having multiple cases, components, or members. According to Yin (2009), the findings generated from multiple case study research are more robust due to the literal or theoretical replication of themes across multiple cases. Additionally, replication logic provides external validation to research findings since case study research is dependent on analytical generalisation as opposed to statistical generalisation (Yin, 2009).

3.3 Ensuring research reliability and validity

According to Le Comple and Goetz (1982), validity in scientific research relates to the accuracy and honesty of the research findings, while reliability is concerned with the chosen research methods' ability to generate the same results over multiple testing periods (Wrightsman *et al.*, 1976). Brink (1993) warns that validity and reliability are fundamental aspects of all scientific research and can be determinants of whether the scientific community considers research findings credible and trustworthy or poor. In qualitative research, the instrument used to collect data is generally the researcher themselves, therefore issues such as the researchers' bias, and competency may affect the reliability and validity of the research if they are not addressed (Brink, 1993). Researchers undertaking qualitative research are warned against being myopic in their approach but encouraged to understand their research from the viewpoint of the respondent to avoid researcher biases (Stake, 1995).

To ensure validity in case study research, Quintão *et al.* (2020) suggest that various sources of evidence must be utilised and data must be triangulated, interview transcripts must be reviewed by the respondents, and a clear and rational timeline of events must be defined. According to Shoaib and Mujtaba (2016), data triangulation is crucial in the assessment of methodological rigour. Brink (1993) provides a list of steps that researchers can follow to ensure the credibility of their research.

1. Repetition logic and thick description:

Research findings must be subject to multiple repetitions and testing over different points of time, in different contexts and by different investigators. The validity and reliability of qualitative research can only be verified if the context in which the study is undertaken is clearly and comprehensively defined together with a detailed description of all procedures followed during the research process. This is what is known as auditability and is concerned with the ability of third parties to understand the logic of a study by following the progression of events in the research (Beck, 1993).

2. Independent expert review:

Consultation should be made with experts that are familiar with the topic being investigated at various stages during the research process.

3. Member checks:

Interview transcripts as well as the conclusions drawn after the analysis process are shared with the respondents to verify and provide feedback about the correctness of the information (Merriam, 2002; Quintão *et al.*, 2020).

4. Checking for invalidating evidence:

The researcher must actively search for any available evidence that may contradict what is held to be true and correct using purposeful sampling and conducting extended engagements with respondents (Patton, 1999). In line with the view held by Cronbach and Meehl (1955) that a proposition can only be accepted as true only once attempts to falsify it have failed.

5. Examination of representativeness:

The representativeness of all data, coding categories and cases used in the analysis and presentation of data must be examined.

To ensure the trustworthiness and dependability of this study, the researcher employed some of the strategies discussed in the above section. Firstly, data were triangulated through the use of multiple sources of data to identify and validate any emerging findings (Oppermann, 2000; Yin, 2017). Secondly, interview transcripts were shared with respondents to confirm whether what has been recorded is what was said and meant (Brink, 1993; Merriam, 2002; Quintão *et al.*, 2020). Thirdly, inductive analysis was used to identify themes in the interview transcripts, as this also allowed the researcher to check for contradicting themes in the data (Cronbach and Meehl, 1955; Patton, 1999). Lastly, an audit trail was prepared which detailed the methods of data collection and analysis used in the study as well as the rationale behind the decisions taken (Beck, 1993).

3.4 Unit of analysis

According to Yin (2009) and Patton (2002), the unit of analysis is a fundamental concept that is connected to the understanding, formulation and implementation of a case study. Dolma (2010) defines a unit of analysis as the object that is being examined in a scientific study and

further states that the researcher's ability to correctly determine the unit of analysis of a study greatly affects the research outcomes. Similarly, Lune and Berg (2017), argue that the focus of a case study is defined by the unit of analysis which may take the form of a single person, a group of people, an organisation or a place. Furthermore, Grünbaum (2007) notes that a unit of analysis could be a group of individuals or their actions.

This study aims to answer the research question "What is the impact of green low-cost social housing on the well-being of the occupants?" Thus, occupant well-being in green buildings becomes the focus of the study, while the different buildings where the participants of the study reside are the case study and the unit of analysis is each participant that will be interviewed for data collection.

3.5 Sampling strategy

According to Landreneau and Creek (2009), a sampling strategy is a plan that is devised to ensure the sample used in a research study represents the population from which the sample is drawn and thus, enables the findings to be generalised across the broader population or field of study. Robinson (2014) asserts that the first step in a sample strategy should be the target sample and further defines it as the entirety of persons from which cases may justifiably be sampled in an interview study. To define a sample target Luborsky and Rubinstein (1995) and Patton (1990) propose that the researcher specify a set of inclusion or exclusion conditions or a combination of both. Inclusion conditions specify certain characteristics that cases must have to be considered for the study, while exclusion conditions specify characteristics that prohibit a case from participating in the study (Robinson, 2014). The inclusion condition for the sample target was for respondents to reside in a low-income social housing building with specific green features since the study aimed to understand the relationship between green social housing buildings and occupant well-being.

The study employed a combination of convenient and purposive sampling approaches in that the participants were specifically selected based on the researchers' a-priori understanding of the research topic and that a specific category of individuals would provide invaluable insight into the phenomenon being researched (Trost, 1986; Mason, 2017). While it was not a requirement for buildings to have a green rating by the GBCSA, the buildings had to possess the following key green features:

(i) Thermal efficiency is concerned with the buildings' ability to retain warmth in cold weather while remaining cool in hot weather thereby reducing or eliminating the need for artificial heating and cooling (Simona *et al.*, 2017).

(ii) Sustainable water heating relates to the implementation of energy-efficient or renewable energy source technologies to heat domestic water and thus reducing energy consumption and associated costs (Pomianowski *et al.*, 2020).

(iii) Efficient lighting, speaks to the incorporation of energy-efficient lighting systems and innovative design strategies to maximise natural light to reduce energy consumption (Barnes, 2012; Sujit Kumar Patro, 2016).

The ideographic nature of the research influenced the sample size used in this study. According to Robinson (2014), studies that have an ideographic objective generally make use of small sample sizes that allow individual cases to have an identifiable voice within the research and further allow the researcher to intensively analyse each case (Robinson *et al.*, 2013).

3.6 Data collection method

Barrett and Twycross (2018) assert that qualitative research requires data which is rich, distinct and holistic to provide the researcher with deep insight and a better understanding of the experiences of participants in a study and through careful analysis, identify emergent themes. Data collection in qualitative research comes in various forms, including observations, visual analysis and individual or group interviews (Silverman, 2021). The following section discusses the data collection method utilised in this study and the justification thereof, followed by the interview questions used and the corresponding sources.

3.6.1 Interviews

To understand the relationship between green building and occupant well-being and how that impacts environmental consciousness, the study required that the chosen data collection method allow respondents to freely express their opinions, feelings, motivations and interests and thus, interviews were selected as the preferred method for data collection.

Hull (1985) defines an interview as a conversation in which participants talk for a specific and deliberate purpose. Alamri (2019) asserts that it is a dialogue between two individuals that focuses on specific human or social concerns. Seidman (2006) states that interviews are a

fundamental means of enquiry driven by an interest in the stories of other people as they are believed to be of value. Similarly, Adhabi and Anozie (2017) describe an interview as a form of consultation in which the interviewer seeks to gain deeper insight into an issue as opinionated by the interviewee. Schostak (2005) provides a similar definition in that interviews are prolonged conversations between two or more persons that aim to generate in-depth information about a specific topic and thus enabling the interpretation of a phenomenon through meanings provided by the interviewees.

Kvale (1994) suggests that using interviews as a data collection technique allows the researcher to gain a greater understanding of the interviewees' perceptions through the interpretation of the described phenomena. The flexible nature of interviews creates an environment in which both the researcher and case can elaborate on the research subject to maximise the depth of responses or ideas (Alamri, 2019). The interactivity of interviews allows the researcher to push for responses that are clear and complete and to explore any emerging themes or topics, thus broadening the scope of understanding of the phenomena being investigated (Alshenqeeti, 2014). According to Gill *et al.* (2008), qualitative interviews are fundamental to data collection. Equally, Cohen *et al.* (2002) assert that interviewing as a data collection method is key in the exploration of structure and negotiation of meanings in a natural environment.

3.6.2 Semi-structured interviews

According to Barrett and Twycross (2018), interviews are a direct and straightforward approach to collecting rich and comprehensive data concerning a specific phenomenon. The authors further state that when using interviews to collect data, the type of interview can be customised to suit the research question, participant attributes and the researchers' preferred approach. The fundamental variation between the types of interviews relates to the degree of structure (Barrett and Twycross, 2018). Interviews are classified into three categories, open or unstructured, semi-structured and structured (Gill *et al.*, 2008). For this study, semi-structured interviews were selected as the preferred method of data collection as the researcher aimed to guide the direction of the interview, asking key questions to define the topic being explored while still allowing flexibility for participants to freely express themselves and elaborate on ideas and responses (Dörnyei, 2007; Alamri, 2019).

A semi-structured interview is an exploratory discussion that is guided by questions that are linked to a phenomenon being investigated (Magaldi and Berler, 2020). Unlike structured

interviews, a semi-structured interview has no rigid adherence, this implies that while the interview may be guided by a set of preset questions, the researcher is afforded the flexibility to tailor the interview questions to the responses given by the participant and thus enrich the quality of data collected (DiCicco-Bloom and Crabtree, 2006; Adhabi and Anozie, 2017). Semi-structured interviews allow researchers to harvest detailed descriptions of interviewees' beliefs, perceptions and interpretations of a specific topic (De Vos *et al.*, 2011).

To gain access to data collection sites, the researcher set up an appointment with the complex manager in Case study 1, to discuss the purpose of the research and the best suitable means to meet potential respondents, after which a site visit to the complex was conducted and potential participants identified and requested to participate in the study. In Case studies 2 and 3, the developments are not managed by a body corporate, the researcher requested the assistance of the Building Control Section of the City of Cape Town Municipality to assist in sharing the purpose of the research and identifying potential participants. A site visit was then conducted together with the building inspector for the area to meet the occupants of the buildings and request their participation in the study.

The semi-structured interviews conducted for this study employed an interview schedule that consisted of ten open-ended questions with additional questions that could be asked depending on the response to the main questions.

3.6.3 Interview Questions

Question:
1. How long have you stayed in the complex?
Reason and source of question:
To establish whether the respondent has resided in the complex long enough to have experienced any of the claimed benefits.
Question:
2. Where did you reside before moving into the complex?
Reason and source of question:
The previous place of residence can serve as a benchmark from which the respondent can refer when making a comparison.
Question:
3. Are you familiar with the concept of green building?
Reason and source of question:
To establish if the respondent is familiar with the subject of green building and sustainability (Cole, 1999; Nordin *et al.*, 2017; Marsh *et al.*, 2020).
Question:
4. How would you describe your spending on electricity prior to moving into the complex?

Reason and source of question:
To determine historic household expenditure on energy (Chester and Morris, 2011).
Question:
5. Have you ever been unable to settle your municipal electricity account, been disconnected due to non-payment or been unable to purchase pre-paid electricity?
Reason and source of question:
To determine the impact energy costs, have on low-income households. (Blocker, 1985; Chester and Morris, 2011; Hernández, 2016; Jessel *et al.*, 2019).
Question:
6. If yes, would you say the incident described above caused or contributed to your stress?
To establish if a link exists between energy poverty and stress-related health complications (Harrington *et al.*, 2005; Hills, 2011).
Question:
7. Have you experienced a reduction in your electricity expenses since moving into the complex?
Reason and source of question:
To determine if the implementation of green solutions translates to reduced energy consumption (Moore, Ridley, *et al.*, 2017; GBCSA, 2019).
Question:
8. If yes, how would you rate the significance of the reduction?
Reason and source of question:
To determine whether a reduction in energy expenses positively impacts the respondents' financial well-being (Moore, Ridley, *et al.*, 2017).
Question:
9. How would you describe the quality of your sleep since moving into the complex?
Reason and source of question:
To establish if a link exists between the improved thermal comfort and air quality of green buildings and occupants' sleeping health (Lan *et al.*, 2014).
Question:
10. Do you think that as people we have a responsibility to protect the environment even if it is at the cost of development?
To gauge the respondents' environmental attitudes (Chawla, 1998; Kollmuss and Agyeman, 2002; Nemcsicsné Zsóka, 2008)
Question:
11. Would you say staying in a green building has influenced your attitude towards the conservation of the environment?
Reason and source of question:
To establish the impact that green buildings have on occupants' environmental awareness (McCunn and Gifford, 2012).
Question:
12. If yes, what actions are you actively taking to play your part in the conservation of the environment?
Reason and source of question:
To establish if environmental awareness creates a sense of obligation to act towards saving the environment (Dunlap *et al.*, 2000)

Table 3 .1 – Semi-structured interview questions

3.6.4 Respondent labelling

To participate in the study, the respondents were assured confidentiality and anonymity. According to Oltmann (2016), anonymity in research relates to the collection of information that does not expose the respondents' identity. The author further defines confidentiality as the researchers' ethical obligation in ensuring that any identifying information is kept from persons not connected to the research. To ensure anonymity and confidentiality and to encourage respondent disclosure, the labelling of respondents was such that participants could only be identified through their responses only by the researcher. As previously indicated, research data was collected at three different locations and for each, a varying number of interviews were conducted, therefore, the respondent labelling was structured as follows:

CS	Number	R	Number	Superscript number
Case study	A number indicating which of the three case studies the respondent participated in	Respondent	A number indicating a specific respondent in a case study	A number indicating how long the respondent has occupied the building, i.e 0.5 years = 6 months.

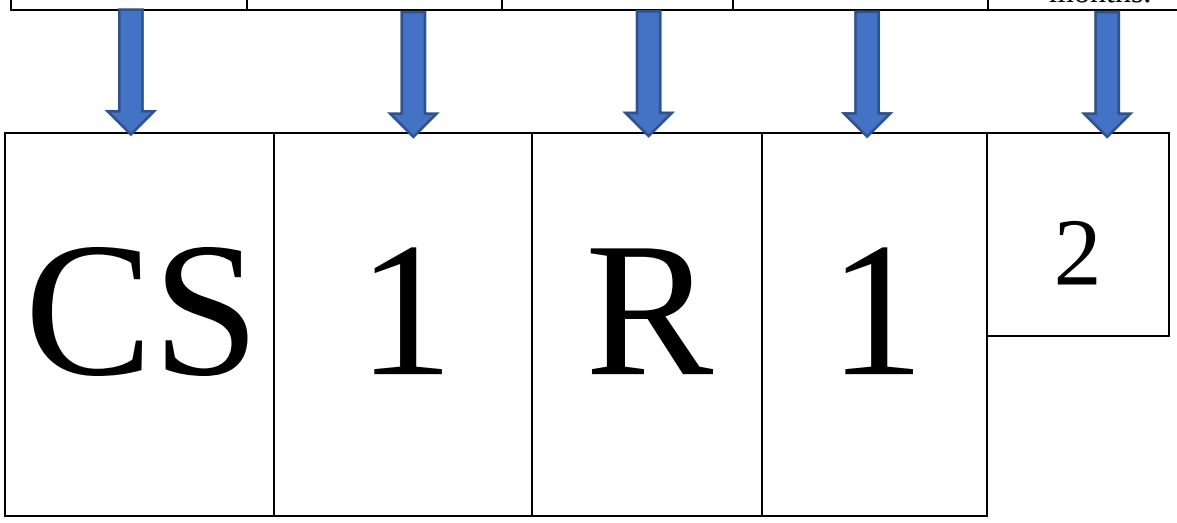

Table 3.2 – Respondent labelling

3.7 Data analysis method

The objective of data analysis in qualitative research is to provide meaning to a situation, this is in contrast to quantitative data analysis which aims to find or confirm the truth in a supposition (Rabiee, 2004). According to Yin (2009), data analysis is composed of several

stages that include the examination, categorisation and tabulation of collected data to address the research aim. Furthermore, Krueger (2014) maintains that the analysis of data should be guided by the research aim. In this study, the collection of data was through using semi-structured interviews with occupants of identified low-cost social housing with green features. The collected data was cleaned, arranged, and then sifted using thematic analysis to identify themes that are pertinent to the research question. Data coding and cross-case analysis were done using data qualitative data analysis software, NVivo.

3.7.1 Thematic analysis

Thematic analysis is a method used in the analysis of qualitative data that focuses on searching for, and identifying recurring ideas or themes in a textual data set (Riger and Sigurvinsdottir, 2016). Similarly, Braun and Clarke (2006) suggest that thematic analysis is used to extract meaning and ideas from textual data and involves identifying, analysing and logging themes. The authors further state that thematic analysis operates as a method as opposed to a methodology, it is not bound to a specific epistemological or theoretical perspective and that results in a highly flexible analysis method (Maguire and Delahunt, 2017). According to Alhojailan (2012), by using thematic analysis the researcher can determine the exact relationships between ideas and examine them against the replicated data.

3.7.2 Justification for using thematic analysis

The qualitative nature of this research required that the researcher be able to draw interpretations that are consistent with the collected data. Thematic analysis can detect and identify variables that affect any idea or interpretation generated by the research participants, these interpretations are crucial in providing explanations for the thoughts, actions and behaviours of the participants, in this instance the occupants of low-cost social housing with green features (Alhojailan, 2012; Creswell and Creswell, 2017). According to Braun and Clarke (2006), thematic analysis is a fundamental method for any qualitative analysis as it equips the researcher with the minimum competency skills required to conduct other forms of qualitative analysis as they are generally thematic. Thematic analysis can be used in both inductive and deductive methodologies (Frith and Gleeson, 2004), in an inductive method, the identified themes are linked to the collected data (Patton, 2002). Conversely, a deductive approach means that the thematic analysis is guided by the researcher's theoretical framework.

Braun and Clarke (2006) suggest that the inherent flexibility of thematic analysis provides a structure on which themes are organised and contributes to the interpretation of the research question. Similarly, the use of thematic analysis in this study allowed the researcher to organise emerging ideas into themes that provided meaning and addressed the research question.

Notwithstanding the above-stated benefits of thematic analysis, the method has some drawbacks that the researcher should be cautious about. Braun and Clarke (2006) state that limited literature exists on the thematic analysis method, and this results in neophyte researchers being uncertain about the procedure for conducting a rigorous thematic analysis. As previously stated, the flexibility of thematic analysis means that the method can incorporate various epistemological positions as it is not linked to pre-existing theoretical frameworks (Braun and Clarke, 2006). Holloway and Todres (2003) argue that the inherent flexibility of thematic analysis can result in inconsistency and incoherence during the development of themes derived from the research data. To resolve the challenges of inconsistency and incoherence, Holloway and Todres (2003) suggest that the researcher make clear the epistemological position that can comprehensibly reinforce the empirical claims of the research. Similarly, Willig (2013) suggests that a clear epistemological position guides how the data is interpreted and regulates how meaning is theorised.

According to Braun and Clarke (2006), thematic analysis requires that the researcher reflects on several choices that need to be made about their study. The first is a reflection on what the researcher considers to be a theme. For this study, a theme was defined as a recurring idea or thought that was considered to encompass something of value towards answering the research question (Braun and Clarke, 2006). Moreover, Braun and Clarke (2006) warn researchers against the use of interview questions as themes, they argue that doing so indicates that the researcher did not apply rigour in analysing the data but instead merely organised and summarised it. In this study, the interview questions simply served as a guide for the conversation and the interview format provided the flexibility for respondents to speak freely and openly (Dörnyei, 2007; Alamri, 2019), themes were then drawn from their responses. Next, the researcher should decide whether themes are going to be identified using an inductive or deductive approach (Braun and Clarke, 2006). This study took a deductive approach in that it was researcher-driven (Braun and Clarke, 2006), and the data was analysed based on themes that were identified during the literature review chapter and also allowed for the discovery of emergent themes (Dawadi, 2021). Lastly, Braun and Clarke (2006) suggest that the researcher decides on the level at which themes will be identified, either at a semantic level or at a latent

level. An analysis of themes identified at a semantic level provides surface-level meaning that does not require interpretation beyond the participant's response (Boyatzis, 1998; Braun and Clarke, 2006). In contrast, a latent-level thematic analysis studies the frameworks that underpin the meanings generated at a semantic level (Braun and Clarke, 2006). This study adopted a latent level of analysis as the researcher sought to understand and interpret the underlying ideas, feelings and beliefs from the participants' responses (Braun and Clarke, 2006).

Within the limited literature that is available on thematic analysis, various guides exist that outline how to conduct variations of thematic analysis (Aronson, 1995; Boyatzis, 1998; Attride-Stirling, 2001; Braun and Clarke, 2006). For this study, the researcher adopted the method outlined by Braun and Clarke (2006) as it is the most commonly used thematic analysis method in qualitative literature (Terry *et al.*, 2017). In their analysis, Braun and Clarke (2006) propose six phases that the researcher needs to follow when conducting a thematic analysis, these are summarised in table 3.3.

Phase	**Process description**
1. Familiarisation with data	The researcher gains familiarity with the data through transcribing data and continuous reading and engagement with the data (Rubin and Rubin, 2011)
2. Generating initial codes	Important analytic ideas contained in the data which may be relevant to addressing the research question are identified and linked to codes (Clarke and Braun, 2013)
3. Searching for themes	Codes that relate to specific concepts are grouped to establish themes
4. Reviewing themes	Themes are checked against the data, editing, integrating or removing themes thereby establishing a preliminary thematic map
5. Defining and naming themes	Developing and refining the thematic map to allow final themes to be selected. Themes are named and given clear descriptions

6. Producing report	Generating a succinct and articulate report consisting of extracts from the data that illustrate themes and analysing them against the research question

Table 3.3 – Thematic analysis phases adapted from Braun and Clarke (2006)

3.7.3 Cross-case analysis

Generally used as an umbrella term for methods that analyse multiple case studies to generate a synthesised outcome (Khan and VanWynsberghe, 2008), a cross-case analysis is a method that enables the researcher to compare commonalities and distinctions across case studies (Cruzes *et al.*, 2015). The cross-case analysis method as proposed by Miles and Huberman (1994) is composed of three synchronised flows of activities: data reduction, data display and drawing and verification of conclusions (Cruzes *et al.*, 2015).

Data reduction refers to the process of organising, selecting, simplifying and transforming data for manageability and intelligibility in terms of study purpose (Miles and Huberman, 1994). Data display is the display of information in an organised, and well-organised assembly that enables the researcher to draw conclusions (Cruzes *et al.*, 2015). To verify the conclusions drawn, the researcher tests emergent meanings from the data for credibility, robustness and validity (Cruzes *et al.*, 2015).

3.8 Chapter Summary

This chapter sought to outline the method with which the research was conducted, describing the adopted research philosophy and the justification thereof. Furthermore, the chapter discussed the participant selection process, the methods used to collect data as well as the adopted data analysis approach.

The study employed an interpretivism research philosophy which guided the researcher in terms of the methods and instruments required to address the research question. A qualitative research method was selected as the most suitable for meeting the research objectives. A qualitative data collection strategy was adopted which drew on primary data derived from semi-structured interviews. The sampling strategy employed was a combination of convenience and purposive sampling, and the inclusion criteria were for respondents to reside in a low-income

social housing building with specific green features. To analyse the data, the study employed a thematic analysis method which identified themes that were relevant to the research question.

Chapter 4: Findings and Data Analysis

4.1 Introduction

This chapter presents a discussion of the findings from the data collection process. A series of interviews were conducted with the occupants of social housing developments with green features at three different locations, each of which formed a case study. An analysis of the transcribed data enabled the researcher to identify recurring ideas that are relevant to the research objective, these were then examined for consistency with the literature. A cross-case analysis was then conducted which allowed the researcher to compare commonalities and distinctions from the interview responses provided by the respondents from the three different case studies.

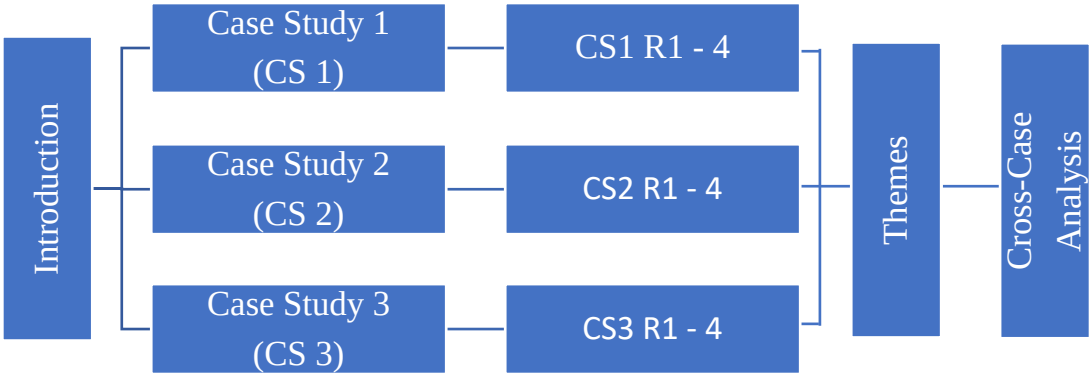

Figure 4.1 – Chapter overview

4.2 Case Study 1

Overview

Case study 1 is a low-income social housing residential complex that comprises 630 units with a total of 21 886m^2 of floor area. 70% of the units cater to occupants who earn a monthly income ranging from R3500 to R7000, while the remaining 30% provide accommodation to households with a combined monthly income that is less than R3500. The development was awarded a Final Edge Certification (FEC) in March 2018 by the GBCSA. Interviews were conducted with four tenants occupying various units in the complex. The buildings contained the following green features:

- Reduced window-to-wall ratio
- Industrial heat pump
- Natural ventilation
- Roof insulation
- Low-E coated glass windows
- Smart electricity meters
- Energy-saving lighting.
- Natural gardens and landscaping

4.2.1 Green Building and Features

CS1R1^2 reported being aware of the concept of green building as she had a background in environmental studies. The respondent informed that she only became aware that the building had green features such as energy-efficient heat pumps, efficient lighting, improved natural ventilation and smart meter boxes during the compulsory induction workshop for new tenants. CS1R1^2 stated that during their two-year stay at the complex they had experienced the benefits of the building's green features which had an impact on how they performed at work. The respondent reports reduced spending on electricity, improved sleep due to optimal thermal conditions and ventilation as well as improved performance at work. This confirms the findings by Lan *et al.* (2014), Harris and Krueger (2017) and Ishibashi and Shimura (2020) that IAQ has a direct impact on sleep which impacts productivity. Additionally, CS1R1^2 stated that the views into the natural gardens that surround the complex buildings provide a sense of calm and relaxation, which is in line with the findings by Ne'Eman (1974) and Boyce *et al.* (2003) that

access to daylight and window views positively impacts the well-being and psychological functioning of occupants in a building.

"The flats open out to beautiful greenery and park-like spaces for the children to play, this is very calming and relaxing to look at." - CS1R1[2]

A comparison between the respondents' current expenditure on electricity versus that of their previous place of residence indicated a significant reduction. CS1R1[2] stated that they used to spend a significant amount on electricity as their home was not fitted with any green features or energy-saving technologies, the respondent reported having tempered with the electricity in an attempt to reduce the monthly electricity bill. This coincides with the findings by Blocker (1985), Hernández (2016) and Jessel *et al.* (2019) who assert that low-income households are severely impacted by continuously increasing energy costs, this is because their financial situation often results in the inability to pay their electrical bills, which often results in a disconnection by the service provider.

"…we would sometimes prioritise buying food over worrying about municipal services. So, we have been disconnected due to a lack of payment. Both for water and electricity." - CS1R1[2]

"The stress of the whole situation resulted in my dad resorting to making use of an illegal connection just for us to have electricity in our household. But Eskom came knocking and found out about the illegal connection and we had to pay back the money for all the time when the illegal connection was in place as well as a reconnection fee or risk being permanently disconnected" - CS1R1[2]

4.2.2 Well-being

When questioned about how their overall well-being was impacted since moving into the complex, CS1R1[2] reported that they had experienced an improvement in their overall well-being and attributed this to the reduction in financial stress. The respondent informed that the energy efficiency of the building allowed them to save on electricity spending, thus allowing them to have more money to use elsewhere or to save for emergencies. The respondent also spoke about the shame and embarrassment they experienced at their previous home when they were unable to make payments for utilities and how that negatively impacted their mental well-being and their relationship with others.

"I think mentally I am at a better place, and I would say that this is largely driven by where I am financially. I sleep better knowing I can afford to keep the lights on and put food on the table without having to compromise one for the other" - CS1R1[2]

4.2.3 Environmental awareness

CS1R1[2] advocated for a balance between development and environmental conservation and felt that green buildings such as the one they occupied served as a good example of what is possible when that balance is achieved. The respondent spoke of the importance of the educational aspects that came with occupying a green building, suggesting that educating tenants about the buildings they occupy encouraged them to be environmentally conscious. This confirms the suggestion by McCunn and Gifford (2012) that providing information about green buildings to building tenants is likely to influence their environmental awareness. When questioned about the impact living in a green building has had on their environmental outlook, the respondent expressed feeling a renewed sense of commitment to environmental conservation since moving into the building.

4.2.1.2 CS1R2[2]

Green Building and Features

CS1R2[2] was relatively new to the complex and informed that she had a basic understanding of the green building and its benefits, the respondent further stated that the green features of the complex buildings were one of the factors that influenced her decision to want to stay in the complex. CS1R2[2] reported that she benefited from the interview workshop that was conducted by the complex management as she was brought up to speed about the different green features of the buildings and how to maximise their functionality to her benefit and the environment. CS1R2[2] reported a significant decrease in her monthly spending on electricity and attributed the large saving to the efficiency of the water heating system installed in the complex buildings, the respondent informed that the savings allowed her to do more for the household.

"I have experienced a definite reduction in my monthly spending. I have natural light and ventilation in my unit so I do not need an air conditioner or a fan." "...I think the bulk of the savings come from the heat pump, heating a geyser depletes electricity units very quickly so

here we only pay for the hot water that we have used and not the amount that has been heated." – CS1R2[2]

Well-being

CS1R2[2] reported a noticeable improvement in their overall well-being since occupying their unit, the respondent indicated that they had experienced a reduction in their financial burdens and likened it to having weight removed from their shoulders. CS1R2[2] stated that the financial benefits, the environment and access to green outdoor spaces made them feel good and in high spirits, the respondent mentioned that they had no more anxiety and had adopted a better outlook on life. This validates the observation made by Kaplan and Kaplan (1989) that natural views through windows reduced frustration, increased life satisfaction and improved health.

"I now live my life without anxiety as I do not feel financially burdened, I have a positive outlook on life and I generally just feel good. I think this has to do with not only the financial benefits I am experiencing staying here but also the environment" – CS1R2[2]

"During the day there is natural light shining through the window, there is a cool breeze and I have a view out onto the green grass and trees. These things provide relaxation for my mind and spirit." - CS1R2[2]

Environmental awareness

CS1R2[2] reported that for them a balance between development and environmental conservation was important. The respondent further indicated that they felt that their attitude towards the environment had been impacted by their stay in a green building. According to the respondent, the change in attitude was mainly because of the workshops that were conducted when they moved into the complex which created a sense of concern for the environment and a call to action. The respondent indicated that they had not begun actively participating in efforts to protect the environment outside of the basic measures that were discussed during the workshops.

4.2.1.3 CSR3[5]

Green Building and Features

CS1R3[5] has been staying in the complex for five years. The respondent informed that before moving into the complex, they had rented a cottage which had no green features, the most basic of which is passive cooling through methods such as cross-ventilation and the stack effect as indicated by Aldawoud (2017) and Santamouris and Asimakopoulos (1996). CS1R3[5] reported that the opening of windows did not improve the thermal comfort in the cottage as it remained warm and humid during hot days and this required that a fan be used which drew a significant amount of electricity. The respondent further stated that the cottage received a limited amount of natural light during the day and therefore required that the lights be kept on. In comparison, the respondent reported that the design of the flat they currently occupied incorporates passive cooling and allows for a desirable amount of natural light to filter in during the day, therefore, eliminating the need for fans for air circulation and keeping the lights on during the day, which saves the respondent money. The respondents' experience in their new place supports the findings by Moore, Nicholls, *et al.* (2017) that the implementation of green building strategies limits the need for mechanical ventilation and improves the financial well-being of households.

"...it was quite dark inside even during the day so we kept the lights on" "...even with the windows open the inside of the flat stayed hot and stuffy. I had to use a fan just to get some airflow, more especially during the summer months and it used a lot of electricity" - CS1R3[5]

Well-being

CS1R3[5] explained that for them, well-being came from being able to feed and shelter their loved ones and that their new place allowed them to do that. The respondent spoke of the peace and contentment that they felt and further stated that having views of green landscaped gardens brought them tranquillity as noted by Ulrich (1984). CS1R3[5] reported that the quality of their sleep had improved since moving into the complex, they woke up well-rested and could focus at work, they attributed this improvement to the thermal conditions in the flat (Wargocki *et al.*, 2018), limited noise disturbances and reduced financial burden brought on by high utility costs.

"I think this is dependent on what one considers important for their well-being, for me as long as I can put food on the table and provide for my family, ensure everyone in the house is healthy and we have a roof over our heads, that for me is good well-being. I have all those things here"

"I do not spend a lot of money on utilities so I have a little extra left over for food and other things. I would say I am content and at peace." - CS1R3[5]

Environmental awareness

CS1R3[5] expressed that while they were aware of the importance of looking after the environment, moving into a green building amplified their level of environmental consciousness and renewed their commitment to environmental conservation. The respondent called for a balance between environmental conservation and development, further stating that the relationship between man and the environment should not be beneficial to a single side. When questioned about the actions they were taking to fulfil that commitment, the respondent indicated that they instilled the importance of limiting water wastage and not littering in their household.

4.2.1.4 CS1R4[7]

Green Building and Features

CS1R4[7] is one of the earliest tenants to move into the complex with a residency of seven years. The respondent had a basic understanding of the green building concept but stated that the complex being a green building did not influence them to want to stay there instead they were driven by desperation. CS1R4[7] rented a RDP house with a prepaid electricity meter box before moving to the complex and informs that they had times when they went without electricity because the money for purchasing electricity was used for attending to other, more urgent needs. The respondent normalised bathing with cold water and not using the electric heater to save electricity. The situation described by the respondent confirms the findings by ACOSS (2013) and Moore, Nicholls, *et al.* (2017) that low-income households resort to self-rationing of energy usage to a point where thermal comfort is compromised and potentially affects their health. The respondent reported that they had not experienced a similar situation since moving into the complex and living in the building had not only allowed them to save money by reducing their energy spending but also taught them how to plan for the future as they did not intend on staying in the complex indefinitely as they felt they needed afford someone else the opportunity that they had been given.

"I was living from pay cheque to pay cheque so keeping the electricity on was a big struggle for me, sometimes I would go without electricity because I had to prioritise other things with the money needed to purchase electricity." - CS1R4[7]

"I do not think this place is meant to be a long-term home for people, I think it is designed to help people get on their feet by creating an environment that makes it possible to get your head on straight while also saving money so that one day you can go out and build a life for yourself because at that point you would be financially secure and prepared mentally. By so doing, you would be providing the same opportunities that you have experienced to the next person that might be in a desperate situation." - CS1R4[7]

Well-being

CS1R4[7] stated that they had experienced a substantial improvement in their well-being since moving into their unit. The respondent indicated that they felt as though their life was on an upward trajectory since they had reduced financial burdens and could therefore provide more for their family. In line with the suggestion made by Chow (2020) and Pearlin *et al.* (1981) that financial stress is linked to stress and anxiety which result in sleeping difficulties; the respondent reported their new financial situation brought about a feeling of relief from stress and anxiety which led to better sleep quality.

"I have experienced the lowest of lows and this right now is a high point in my life. I have my family with me and I am able to clothe them and put more food on the table. I have no stress or anxiety about waking up tomorrow and not having money for food or electricity so I sleep better." - CS1R4[7]

Environmental awareness

CS1R4[7] stated that they believe man's responsibility to the environment is an instruction that comes directly from God as it is contained in the bible.

"...we need to take care of our environment and the planet as a whole as this was an instruction from God." - CS1R4[7]

The respondent acknowledged the importance of development but argued that man should not be wasteful but should be considerate of future generations. The respondent further reported that staying in a green building and learning about its benefits to people and the environment

had influenced their perception of the environment and prompted them to take basic actions towards its preservation (McCunn and Gifford, 2012).

"…it is only after I learned about what green buildings are and what role they play for the environment did I begin to care more about the environment." - CS1R4[7]

4.2.2 Case Study 2

Overview

Case study 2 is an affordable social housing development that will consist of 870 single and double-bedroom units totalling 36 868m^2 of floor area once completed. The units are divided into five different design typologies that are being constructed in phases. The first phase has been completed and consists of 330 units that take the form of three of the five design typologies. The completed phase received a Preliminary EDGE certificate (PEC) on 19 June 2022. Interviews were conducted with four tenants occupying various units in the complex. The buildings contained the following green features:

- Energy-efficient heat pumps
- Energy-saving lighting
- Natural ventilation
- Reduced window-to-wall ratio
- Low-flow shower heads and faucets
- Integrated rainwater harvesting system
- Roof insulation
- Natural gardens and landscaping

4.2.2.1 CS2R1^2

Green Building and Features

CS2R1^2 indicated that they had a basic knowledge of green building but knew of its benefits, the respondent further stated that they knew that the building was green and that it was a motivator for them to seek residency in the complex as they anticipated a reduction in their monthly expenses. Some of the initiatives implemented in the buildings are heat pumps, energy-efficient lighting and smart electricity meter boxes which were not present at their previous place of residency. The respondent informed that these measures contributed to an estimated 70 per cent reduction in their monthly expenditure on electricity (Kats, 2003; Smallwood, 2015). The significance of the reduction has allowed the respondent to attend to other household essentials such as groceries.

"We did not have the fancy electricity meter that we have here, we also did not have a heat pump so everyday activities such as cooking and heating water for bathing were a lot more

costly to do. I used to pay close to R1000 for electricity and this has been reduced to less than R300 here."- CS2R1[2]

Well-being

When questioned about the environment inside their flat, CS2R1[2] reported that the air was clean and thermal conditions were desirable and they slept better. However, the respondent indicated that they were uncertain whether the fact that they slept better could be attributed to the building design and features or if it was because of their contentment and outlook on life.

"…the air smells clean, the rooms are warm and homely so I sleep quite well and I do not suffer from any respiratory illnesses so I would say it is good." - CS2R1[2]

CS2R1[2] expressed that their financial situation and mental health had improved significantly since moving into the complex, the respondent explained that the reduced utility costs and the free electricity offered much-needed financial relief.

"I would say that my biological and financial well-being has improved. I mentioned that I am in a good place both mentally and physically." - CS2R1[2]

"We pay very little for electricity and water, we get assisted with free electricity, the flats are beautiful and comfortable, and we have lush green spaces to help us relax." – CS2R1[2]

Environmental awareness

CS2R1[2] called for a mutual relationship between development and the environment to be established, one that would find a balance between taking from the environment to enable development and then developing infrastructure that is efficient and friendly to the environment. The respondent reported that staying in a green building had positively impacted their environmental attitude and that teaching tenants about the relationship between green buildings and the environment helps makes them better custodians of the environment (McCunn and Gifford, 2012).

4.2.2.2 CS2R2[2]

Green Building and Features

CS2R2[2] has been residing in the complex for two years and reports that they are not familiar with the concept of green building and that they were not aware that the building is green-rated before moving in. After being given an overview of the green building concept, the respondent mentioned that the claimed benefits of green buildings would have motivated them to want to stay in the building, but mentioned that the cost of rent would be a bigger deciding factor than the claimed benefits. The respondent further reported that they spend significantly less on electricity in their new place since they stay alone and also receive free electricity. The savings they make allow them to afford more food and have petrol money.

"…the extra money that I am saving is used towards paying for petrol for my car or adding groceries that I otherwise would not have been able to afford if I stayed at a different place." - CS2R2[2]

CS2R2[2] attributed the savings they were making to the smart electricity meter boxes installed in the building that regulated how much electricity was drawn at any given time. The respondent explained that the smart meter box in their flat conditioned them to use electricity sparingly and hopes to continue implementing that lesson in future should they move to a different place.

Well-being

CS2R2[2] felt that the improvement in their psychological well-being was driven by the improvement in their financial well-being. When asked about the indoor environmental quality of their unit the respondent reported that they slept well and woke up feeling well-rested each morning which they felt contributed to good health. CS2R2[2] indicated that the savings they made from occupying a green building, together with the free electricity they received enabled them to have a degree of financial flexibility which has had a positive impact on their psychological well-being.

"…having financial well-being has improved my psychological well-being since I am not stressed about not having money, so they are connected." - CS2R2[2]

Environmental awareness

CS2R2[2] indicated that they did not feel that staying in a green building influenced their attitude towards environmental conservation as they have always been of the view that the environment should be protected. However, the respondent also indicated that development, especially that of housing is equally important so a balance needed to be struck and the development of green buildings would provide the required balance. When questioned about their actions towards ensuring environmental conservation, the respondent explained that they recycled, reused and refrained from wasting, they further expressed that their uncertainty about whether their actions were enough to make a difference did not stop them from wanting to contribute.

4.2.2.3 CS2R3[3]

Green Building and Features

CS2R3[3] reported that their decision to want to move into the complex was influenced by the fact that it was a green building. When comparing their experience in the complex against that of their previous place of residency, the respondent indicated that they had experienced a significant reduction in their monthly spending on electricity since moving into the building. The monthly expenditure on electricity at their previous place amounted to just below a thousand rand whereas, in the complex, the respondent reports spending less than two hundred rands. The respondent had experienced electricity disconnections at their previous place of residence due to non-payment, as the respondent used to occupy a flat that did not have a prepaid electricity meter box and this resulted in their household consuming more electricity than they could pay for and ultimately getting disconnected.

The respondent reported that they had not experienced a reoccurrence of the same challenges since moving into the green building, and attributed this to the green features that are implemented in the building such as the smart meter boxes and the heat pumps that controlled their consumption of electricity and hot water respectively. They further explained that staying in the building had a direct impact on their finances as they did not have to exhaust their electricity on mechanical heating and cooling, thereby saving money. When questioned about the indoor environmental quality of the flat they occupied, the respondent described it as being clean and comfortable with optimal thermal conditions and having access to outdoor green spaces which they found to be relaxing.

Well-being

CS2R3[3] reported that their flat provided them with peace of mind, comfort and restful sleep and had a positive impact on their finances, which linked back to their overall well-being since they could save money and afford a bit more (Joo, 1998). The respondent also spoke of the role of natural light and access to green outdoor spaces and how that had a positive impact on how they felt (Ulrich, 1993).

"…I get enough natural light during the day and I get to look at the beautiful greenery which relaxes me, I do not feel cramped." - CS2R3[3]

Environmental awareness

CS2R3[3] reported that staying in a green building made them appreciate the environment and created a desire to act towards preserving it for future generations. The respondent explained that while green buildings were a welcomed step towards achieving environmental preservation, down-scaling and densification were something they viewed as being equally important as they would enable more houses to be developed while limiting the amount of exploitation of the natural environment.

4.2.2.4 CS2R4[1]

Green Building and Features

CS2R4[1] rented a single-bedroom unit not too far from the complex before moving in a year ago. The respondent reported that they were not familiar with the concept of green building but once the interviewer provided clarity, the respondent indicated that the potential to save money would have been a sufficient motivation for them to want to move into the complex. The respondent indicated that they had never experienced a disconnection to their electricity supply or failed to purchase electricity but stated that the cost of electricity at their previous place was a major challenge. The situation was further exacerbated by the fact that they earned very little and did not have a stable income as they were not formally employed but worked as a car mechanic in the townships. When asked to compare their spending on electricity since moving into the complex the respondent informed that they had experienced a significant decrease in how much they spent. CS2R4[1] estimated that they spent around a thousand rands per month on electricity before moving into the complex, a figure which has since been reduced significantly

owing to the energy-saving measures implemented in the complex buildings (Kats, 2003; Yudelson, 2010).

"I will be the first one to tell you that the power-saving measures in place here really work. I used to spend about a thousand rand on my electricity but now I spend about 20% of that…" - CS2R4[1]

Well-being

CS2R4[1] reported that the environment within their flat was conducive to good health because it was properly ventilated and provided a comfortable experience and high-quality breathable air. The statement confirms the findings by Allen *et al.* (2015) that green buildings improve occupant well-being by providing improved indoor air quality which minimises allergies and asthma. The respondent further informed that their life had improved since moving into the complex and attributed that improvement to the financial position that staying in the complex has allowed them to occupy. CS2R4[1] indicated that they save money every month which has had a noticeable impact on their lifestyle as they could afford a bit more for their family. Additionally, the respondent indicated that their stress levels had been reduced since moving into the complex and that they felt that they had a degree of control over their life.

"I find it comfortable and most importantly, it is clean. I am not just referring to the physical appearance of the place but the air too, it does not feel stuffy or unbreathable in there, and the air is clean because the flat is properly ventilated" - CS2R4[1]

Environmental awareness

CS2R4[1] indicated that their environmental attitude was not impacted by staying in a green building, and that the views they held about the subject were not as a result of staying in a green building but that they have always been environmentally conscious. The respondent argued that while the development of housing was important, more could be done to ensure environmental conservation and that green building was a good starting point. When questioned about what they were actively doing for the environment, the respondent indicated that they were looking for ways to become more involved in environmental conservation efforts and being conscious of their electricity consumption was all they were doing at the time being.

4.2.3 Case Study 3

Overview

Case study 3 is a middle and low-income social housing development that comprises 323 affordable housing units of 7 different design typologies. The development was awarded a Final Edge Certification (FEC) in August 2017 by the GBCSA and is one of the first residential housing projects in South Africa to receive FEC. Interviews were conducted with 4 tenants occupying different units in the complex. The buildings contained the following green features:

- Reduced window-to-wall ratio
- Gravity-fed solar water heaters
- Roof insulation
- Low-flow shower heads
- Natural ventilation
- Energy-saving lighting
- Smart electricity meters
- Natural gardens and landscaping

4.2.3.1 CS3R1[4]

Green Building and Features

CS3R1[4] has been living in the building for four years and informs that before moving into the complex they stayed in similar social housing development. The respondent stated that they became familiar with the subject of green buildings when they attended a workshop hosted by the complex management that outlined the basic design and green features of the buildings and how that would affect the user experience. Green features that the respondent was aware of included energy-saving lights, smart electricity meter boxes, roof insulation and solar geysers. The respondent reported not having experienced a noticeable difference in their spending on electricity and doubted the effectiveness of the green measures implemented in the building.

"The place I stayed in did not have the kind of equipment that we have here, it was just an ordinary flat so it should tell you something about this place when I tell you that there is no noticeable difference in what I spent versus what I spend now." – CS3R1[4]

"I was expecting to because of the marketing that was done when we first moved in but I cannot say I have experienced a reduction worth mentioning." - CS3R1[4]

In terms of electricity usage, the above statements by CS3R1[4] contradict the findings made by Kats (2003) and Yudelson (2010) that conventional buildings have an energy demand that is between 30 per cent and 50 per cent higher than that of green buildings.

Well-being

CS3R1[4] reported no experiencing no change in their quality of life or well-being. The respondent described the indoor environment experience as livable and no different to conventional buildings. The respondent expressed that their experience in the building had no meaningful impact on their well-being other than sheltering them. The only green feature that the respondent welcomed was the availability of green outdoor spaces which the respondent described as being relaxing and reported using regularly.

Environmental awareness

CS3R1[4] indicated that staying in a building with green features did not influence how they felt about environmental conservation and the importance thereof. They explained that their background and the challenges relating to housing that they had faced in the past are what shaped their outlook on the issues of environmental preservation. The respondent felt that development should take precedence over environmental conservation and that they rarely participated in efforts to protect the environment.

"I have stayed in an informal settlement before, in a shack with no running water, or electricity and had to make use of a community toilet, which offered very little privacy and safety. So for me, development takes priority over the environment."- CS3R1[4]

4.2.3.2 CS3R2[2]

Green Building and Features

CS3R2[2] moved into the complex two years ago after migrating from the Eastern Cape. The respondent indicated that they were not familiar with the concept of green building. Once the interviewer provided clarity, the respondent expressed that while knowing that the buildings in the complex had green features would have motivated them to want to stay in the complex, the absence of green features would have not deterred them away. The respondent confirmed that

they were aware of some of the green measures implemented on the buildings such as the solar geysers, energy-saving lighting and smart electricity meter boxes which helped reduce their monthly spending on electricity as the units lasted longer (Kats, 2003; Yudelson, 2010).

"…well the cost of electricity is the same but here it lasts longer because of the measures that are put in place. So it makes it feel like it is cheaper when it is not." - CS3R2[2]

The respondent further reported that the design of their unit allowed for ample sunlight into the flat during cold days and experienced a cool flow of air during warmer days which made the thermal condition in the flat optimal and negated the need for fans and heaters, which ultimately saved them money.

Well-being

CS3R2[2] reported having experienced an improvement in their well-being and attributed it to the environment in and around the building they occupied (Moore, Nicholls, *et al.*, 2017). Access to communal green spaces provided a feeling of relaxation and the change in their financial situation positively impacted their overall well-being (Ne'Eman, 1974; Boyce *et al.*, 2003). The respondent expressed having peace of mind, reduced stress and feelings of inadequacy and being generally happy.

"…this place has created an environment where people like myself can feel like they matter and that makes me happy." - CS3R2[2]

Environmental awareness

CS3R2[2] called for environmental conservation to be afforded the same importance as development. The respondent described the relationship between development and the environment as one that should be mutually beneficial, they further argued that taking steps to protect the environment reduces climate change, which in turn reduces natural disasters, and food and water shortages and ultimately ensures the continued well-fair of society.

"Protecting the environment helps us protect ourselves because a clean environment means better health, fewer food shortages and fewer natural disasters." - CS3R2[2]

4.2.3.3 CS3R3[2]

Green Building and Features

CS3R3[1] has been staying in the building for one year after moving out of an RDP house that they were renting in a nearby township. The respondent reported that they were familiar with the concept of green buildings and the benefits associated with green buildings. They further explained that while the benefits were attractive, they were not the main driving factor for them wanting to stay in the building, they were driven by desperation and therefore any available place would have sufficed. A comparison between the respondents' previous place of residence and their current place revealed that there was a noticeable decrease in their spending on water and electricity. The respondent reported that they had experienced situations in which they were unable to purchase electricity and had to borrow money from neighbours, a situation which they described as stressful and embarrassing. The described experience confirms the findings by Hills (2011), which suggests that a connection exists between energy poverty, debt and poor mental health. The respondent reported that they had not experienced a similar situation since occupying the building but have instead noticed a considerable decrease in their energy spending and attributed this to the green measures implemented in the building.

"The solar geysers, smart box and power-saving lights do work, I can see the results of having those things when doing the calculations at the end of each month." – CS3R3[1]

Well-being

CS3R3[1] informed that they felt that their well-being had been positively impacted since occupying the building. The respondent reported that the living conditions in their flat and the financial savings they were experiencing had a positive effect on their health as they lived in a comfortable and healthy environment, and had reduced financial stress which they felt contributed to their overall well-being (Fisk and Rosenfeld, 1997; Ghodrati *et al.*, 2012; Allen *et al.*, 2015).

Environmental awareness

CS3R3[1] expressed that a balance was necessary between development and the conservation of the environment. The respondent stated that development translated into an improved economy, better housing opportunities and job creation and, the importance of development

and environmental conservation co-existing and being given equal priority. The respondent further acknowledged that their position on environmental conservation may have been influenced by their experience living in a green building and that they actively participated in efforts to protect the environment through recycling and reusing.

4.2.3.4 CS3R4[4]

Green Building and Features

CS3R4[4] has been staying in the complex for four years and reported that they were not familiar with the concept of green building. The researcher explained what green building was and asked if the benefits associated with green buildings would have attracted the respondent to move into the complex. The respondent expressed that the health and financial benefits would have motivated them to seek a place in the complex as they aspired to live healthier and save money. The respondent informed the researcher that they were not informed about the features of the buildings and that the only green features they were aware of were the solar geysers on the roof and energy-saving lightbulbs but did not feel that those measures contributed much to reducing what they spent on electricity. This experience contradicts the assertions by Yudelson (2010), Kats (2003) and Smallwood (2015).

"I know there are solar geysers on the roof and the light bulbs used here are said to be energy-saving, although I am not sure if both those things help in any way because we still struggle with electricity" – CS3R4[4]

The indoor comfort of the respondents' flat was a major point of concern which they felt contributed to both health and financial challenges. The respondent indicated that the cold temperature of their flat put them at risk for colds and flu, and forced them to constantly keep the heater on to avoid getting sick. This required that they spend more on electricity, which has led to them adopting the usage of a paraffin heater to save on electricity. However, this has created a new health challenge for them as the fumes from the paraffin heater produce a bad odour and cause headaches.

Well-being

CS3R4[4] reported that they felt that they were forced to make tradeoffs between keeping the lights on and purchasing much-needed household essentials, which they described as being a major cause of stress. The respondent also expressed discontent with the thermal conditions in

their flat. They reported that the temperature in their flat was such that they were at constant risk of catching cold-related illnesses. To mitigate this challenge, the respondent made use of a heater to improve the indoor comfort of their flat, which was not financially feasible as it drew a lot of electricity. The respondent then adopted the use of a paraffin heater to save on electricity while keeping their flat warm but reports experiencing headaches from inhaling the fumes from the burning paraffin. The respondent feels that the challenges they face would be resolved by simply addressing the thermal issues that are affecting the building.

"…during the cold months, I have to choose between a headache or freezing and catching a cold or flu. So my experience inside the flat is not that great." - CS3R4[4]

Environmental awareness

CS3R4[4] argued that development should be prioritised over environmental conservation as people living in difficult circumstances such as those in shacks and informal settlements faced various challenges ranging from malnutrition, HIV/Aids, unemployment and low levels of literacy. The respondent felt that these social ills were more prevalent when development was absent or under-prioritised and therefore felt that prioritising development would save and improve the lives of many.

Case Study 1				
Respondent	**Green features respondent is aware of**	**Respondent's definition of well-being**	**Perceived well-being since occupying a green building**	**Green building impact on respondent environmental awareness**
CS1R1[2]	Enegy-efficient heat pumps. Energy-saving lighting. Smart electricity meter boxes. Passive heating and cooling.	Peace which stems from sound physical and mental health.	Improved financial well-being. Improved sleep due to optimal thermal conditions. Improved psychological well-being due to access to greenery and natural light.	Renewed sense of commitment to environmental conservation. Promoted balance between development and protecting the environment. Practised recycling and considerate usage of water and energy.
CS1R2[2]	Energy-saving lighting. Smart electricity meter boxes. Energy-efficient heat pump. Natural gardens and landscaping.	Sound state of mental and financial health.	Improved financial well-being. Reduced anxiety and improved psychological well-being.	Sense of concern for the environment. Advocated for balance between development and environmental conservation. Not actively participating in environmental conservation in a personal capacity.

CS1R3[5]	Passive heating and cooling. Optimal natural light. Energy-saving lighting.	Good state of health and desirable living conditions.	Improved financial well-being. Improved sleep due to optimal thermal conditions. Improved psychological well-being.	Renewed sense of commitment to environmental conservation. Promoted balance between development and protecting the environment. Encouraged considerate usage of water and not polluting.
CS1R4[7]	Passive heating and cooling. Low-flow shower heads and faucets Energy-efficient heat pump.	Being in a state of good physical, psychological and financial health.	Improved sleep due to optimal thermal conditions. Improved financial well-being. Reduced financial stress. Reduced anxiety and improved psychological well-being.	Empathy, consideration and compulsion to protect the environment. Equated environmental consciousness to a religious obligation. Practised recycling and reusing.

Table 4.2 – Relationship between key research themes for Case Study 1

Case Study 2				
Respondent	**Green features respondent is aware of**	**Respondent's definition of well-being**	**Perceived well-being since occupying a green building**	**Green building impact on respondent environmental awareness**
CS2R1[2]	Passive heating and cooling. Energy-saving lighting. Smart electricity meter boxes. Natural gardens and landscaping. Energy-efficient heat pump.	Sound mental, financial and physical health. Management of stress. Good quality of life.	Improved physical and psychological well-being. Improved financial well-being. Reduced stress.	Greater sense of appreciation for the environment. Teaches and shares information about the environment to promote awareness. Practices recycling and reusing.
CS2R2[2]	Smart electricity meter boxes. Energy-efficient heat pump. Energy-saving lighting.	Good quality of life. Healthy living environment. Mental, psychological and financial well-being.	Reported improvement in psychological well-being. Experienced a degree of financial flexibility. Good sleep health.	Positive environmental attitude but not influenced by occupying a green building. Advocated for balance between development and environmental sustainability. Practices recycling and limits wastage.

CS2R3[3]	Smart electricity meter boxes. Energy-efficient heat pump. Passive heating and cooling. Natural gardens and landscaping.	Comfortable quality of life. Healthy living conditions, mental and financial health.	Reported having peace of mind resulting from improved financial well-being. Restful sleep. Improved disposition.	Desire to act towards environmental preservation. Proposed practical measures to ensure sustainability. Practices recycling and refrains from littering.
CS2R4[1]	Smart electricity meter boxes. Energy-efficient heat pump. Energy-saving lighting. Low-flow shower heads and faucets	Sound psychological health, the reduction of stress and promoting physical and financial health.	Reported experiencing good respiratory health. Improved financial well-being. Feeling in control and experiencing reduced stress.	Positive environmental attitude but not influenced by occupying a green building. Acknowledged the importance of environmental sustainability and the role played by green buildings.

Table 4.3 – Relationship between key research themes for Case Study 2

Case Study 3				
Respondent	**Green features respondent is aware of**	**Respondent's definition of well-being**	**Perceived well-being since occupying a green building**	**Green building impact on respondent environmental awareness**
CS3R1[3]	Gravity-fed solar water heaters. Energy-saving lighting. Roof insulation.	State of contentment. Good health resulting from sound physical, mental and financial well-being.	Reported no noticeable change in financial well-being but stated that natural gardens assisted with relaxation.	Reported no change in environmental attitude. Prioritised development over environmental sustainability. Practiced recycling and reusing.
CS3R2[4]	Energy-saving lighting. Gravity-fed solar water heaters. Low-flow shower heads and faucets Smart electricity meter boxes.	Good, physical, mental and financial health and the absence of stress.	Experienced feeling relaxed. Reported improved well-being. Improved financial well-being and mental health. Expressed feeling happy.	Revived passion for environmental sustainability. Recognizes the importance of protecting the environment and the effect that has on the welfare of society. Actively involved in recycling and reusing.
CS3R3[1]	Smart electricity meter boxes. Gravity-fed solar water heaters. Energy-saving lighting.	State of contentment and good health resulting from sound physical, mental and financial well-being.	Reported improved health. Improved financial well-being. Reduced stress.	Developed interest in sustainability. Advocates for balance between development and environmental preservation.

	Natural gardens and landscaping.			Engages in discussions about sustainability and actively participates in recycling and reusing.
CS3R4[4]	Energy-saving lighting. Gravity-fed solar water heaters.	Being content and in good health financially, emotionally, physically and socially.	Reported increased financial challenges. Health challenges resulting from poor indoor thermal conditions. Increased stress resulting in compromised well-being.	Reported no change in environmental attitude. Prioritised development over environmental sustainability. Practices recycling and reusing.

Table 4.4 – Relationship between key research themes for Case Study 3

4.3 Cross-Case Analysis

This section presents a cross-case analysis of the themes drawn from the data collected from each of the respondents from the three case studies. The analysis method aims to compare the theme commonalities and distinctions across the case studies (Miles and Huberman, 1994). The responses to the semi-structured interview questions provided information on the respondent's perception of how their perceived well-being and environmental consciousness had been affected by occupying a building with green building features.

The identified themes are categorised as follows.

Category	**Description**
Overarching theme	The relationship between green social housing and occupant well-being
Global themes	Green buildings Well-being Environmental awareness
Sub-themes	Green building features Perceived well-being Impact of green buildings on environmental awareness

Table 4.5 – Theme categories

The relationship between green social housing and occupant well-being was identified as the overarching theme. Green buildings and well-being and environmental awareness were identified as the three global themes.

The first global theme, Green buildings; addresses the green features implemented in each building. Green features included a structural design that optimised passive heating and cooling for thermal comfort, energy-efficient lighting and water-heating systems, electricity meter boxes that regulated energy consumption and green outdoor spaces.

The second global theme, Well-being; looks at what respondents define as well-being as it relates to them, respondents are then requested to self-assess their well-being since moving into a green building, which leads to the sub-theme; perceived well-being.

The third global theme, Environmental awareness looks at the impact that green buildings have on the environmental awareness of their occupants and whether that translates into action.

Finally, the overarching theme is; The relationship between green social housing and occupant well-being and aims to determine if a connection exists between green buildings and occupant well-being by asking occupants of green social housing buildings if their well-being had been impacted since moving into a green building.

The three case studies comprising the research all had EDGE certification. However, Case study 3 had a Preliminary EDGE Certification (PEC) at the time of the investigation, contrasting Case studies 1 and 2 which had already obtained their Final EDGE Certification (FEC). It is worth noting that while Case study 3 did not have FEC, most of the green features implemented in Case studies 1 and 2 were also prevalent in Case study 3.

Case study 1	**Case study 2**	**Case study 3**
Reduced window-to-wall ratio	Heat pumps	Reduced window-to-wall ratio
Industrial heat pump	Energy-saving lighting	Gravity-fed solar water heaters
Natural ventilation	Natural ventilation	Roof insulation
Roof insulation	Reduced window-to-wall ratio	Low-flow shower heads
Low-E coated glass windows	Low-flow shower heads and faucets	Natural ventilation
Smart electricity meters	Integrated rainwater harvesting system	Energy-saving lighting
Energy-saving lighting.	Roof insulation	Smart electricity meters
Natural gardens and landscaping	Natural gardens and landscaping	Natural gardens and landscaping

Table 4.6 – Green features implemented in each case study

4.3.1 Green buildings

Green building features

The participants in the study were all aware of some form of a green initiative that was implemented in the building they occupied and how these positively impacted their well-being and their perception of the environment. The respondents indicated that some process of induction was undertaken by the building or complex management before or during the occupation process. This process ensured that occupants were familiar with the different green measures put in place and how best they could maximise their functionality for their benefit and that of the environment. This supports the assertion by Cole (2013) that educating green building occupants about the buildings they occupy is not only beneficial to them in terms of their personal enrichment but may also improve their ability to contribute to the building's overall environmental performance. The validity of this concept is evident in the statement made by CS1R4[7] that their environmental attitude was positively influenced only after learning about green buildings and their impact on the environment.

Moore, Nicholls, *et al.* (2017) suggest that the implementation of green building strategies reduces reliance on mechanical ventilation systems and has a positive impact on the financial situations of households. Kats (2003) and Yudelson (2010) found that conventional buildings have an energy demand that is between 30 per cent and 50 per cent higher than that of green buildings. The green initiatives most prevalent in each case study included passive heating and cooling mechanisms and natural ventilation, roof insulation, efficient water heating systems, and smart electricity meter boxes. The study indicated that all respondents with the exception of CS3R1[4] and CS3R4[4] expressed having been positively impacted by the implementation of the green initiatives in their buildings. Respondent CS3R1[4] informed that they had not experienced a noticeable reduction in their energy spending and questioned the legitimacy of the claims made about the benefits of green buildings. Similarly, CS3R4[4] stated that the green initiatives implemented in the building did not translate into a reduction in their energy spending.

The experiences of the respondents contradict the findings by Kats (2003), Yudelson (2010) and Moore, Nicholls, *et al.* (2017). However, it is worth noting that respondents CS3R1[4] and CS3R4[4] account for only 17 per cent of the sample group and that the remainder of the respondents expressed having experienced positive outcomes as a result of the green initiatives implemented in their buildings. All of the respondents in Case studies 1 and 2 as well as

respondents CS3R2[2] and CS3R3[2] from Case study 3 reported having experienced a reduction in their energy spending and improved indoor thermal conditions (Lan *et al.*, 2014; Smallwood, 2015; Moore, Nicholls, *et al.*, 2017).

4.3.2 Well-being

Research suggests that buildings that encompass natural features and provide a link to the natural environment are conducive to the well-being and function of occupants (Kaplan and Kaplan, 1989; Orians and Heerwagen, 1992; Kellert and Wilson, 1993). Well-being as a concept is linked to an individual's perceived quality of life, physical and mental health, the feeling of happiness, satisfaction or contentment and is subjective and relative (Ryan and Deci, 2001; McMahon, 2006; Bergdolt, 2008; Camfield and Skevington, 2008; McDowell, 2010). The study required that respondents define what they perceived as well-being and the relevant contributing factors. The exercise revealed that respondents considered physical and psychological health as well as financial well-being as key contributors to overall well-being. The literature suggests that all these factors are directly and indirectly affected by the buildings they occupied (Harrington *et al.*, 2005; Hoffman and Henn, 2008; Zigenfus, 2008; Ghodrati *et al.*, 2012; Allen *et al.*, 2015; Moore, Nicholls, *et al.*, 2017).

Physical and psychological health:

Pearce (2003) proposes that a building that employs sound design principles has a positive impact on the physical and psychological health and well-being of occupants. Similarly, Zigenfus (2008) suggests that this positive impact is made possible by employing environmentally friendly materials and operational elements in the design and construction of buildings. All the respondents from the three case studies identified physical and psychological health as a priority and a key contributor to well-being. When questioned about their experience in the buildings as it relates to their physical and psychological health, 11 of the 12 respondents from across all 3 case studies expressed having experienced some form of improvement in their physical and psychological health. Respondents reported experiencing a reduction in stress and anxiety, better sleep quality and functioning as well as feelings of calm and relaxation. Respondent CS3R4[4] was the exception, the respondent reported experiencing adverse health

conditions which they attributed to the poor indoor thermal conditions in their flat and elevated stress which was a result of financial challenges.

Financial well-being:

All respondents except for respondents CS1R1[2] and CS1R3[5] identified financial well-being as a major contributing factor to their well-being. 83 per cent of the respondents from all three case studies confirmed having experienced an improvement in their financial well-being. The majority of the respondents attributed the improvement to the energy-efficient water heating systems and passive heating and cooling interventions implemented in the buildings. However, respondent CS3R1[3] reported not experiencing any noticeable change in their financial situation while respondent CS3R4[4] expressed having experienced an adverse effect increase in their financial well-being, citing increased financial challenges brought on by poor indoor thermal conditions.

4.3.3 Environmental awareness

The literature provides various definitions for environmental awareness however, a key theme in the literature's definitions is that action and behaviour are influenced by awareness. Individuals are likely to take environmentally-friendly action or participate in environmental organisations if they are psychologically and emotionally motivated (Altin *et al.*, 2014; Mei *et al.*, 2016). In Case study 1, respondents CS1R1[2], CS1R2[2] and CS1R3[5] indicated that they had undergone some form of induction when they moved into the building which familiarised them with the concepts of green building and sustainability and the role they play in the environment. In Case study 2, only respondents CS2R1[2] and CS2R3[3] reported having undergone induction when moving into the building. Lastly, in Case study 3 only respondent CS3R1[4] reported having undergone induction. However, all the respondents from across the 3 case studies except for respondents CS3R1[4] and CS3R4[4], indicated that they were aware of the green features in the buildings they occupied and reported having experienced some of the benefits linked to occupying a green building. When questioned about their environmental awareness and the actions they were taking to promote environmental conservation, all the respondents except for respondents CS3R1[4] and CS3R4[4] reported experiencing a positive influence on their environmental awareness since moving into the green buildings. The consensus among respondents was that a balance between development and environmental conservation needed to be achieved to ensure a sustainable future for all. However, respondents CS3R1[4] and CS3R4[4]

argued that development should be prioritised over environmental conservation as they felt development was crucial to the development of the economy, creating jobs and improving the lives of people. Interestingly, while respondents CS3R1[4] and CS3R4[4] shared contrasting views to the rest of the respondents on the subject of development versus environmental conservation, all respondents reported being actively involved in activities that promote environmental conservation.

4.3.4 Relationship between green building and well-being and its impact on environmental awareness

Based on the findings and the literature, conclusions were drawn on whether a relationship exists between green buildings and occupant well-being as well as how occupying a green building impacted the environmental awareness and attitude of occupants. Given that all respondents reported being aware of the green building initiatives implemented in their respective buildings and that 83 per cent of the respondents reported having experienced improvement in the areas which they perceived to be crucial to their well-being. Furthermore, 83 per cent of the respondents reported experiencing a positive influence on their environmental awareness and attitude since occupying their respective buildings.

Table 4.6 exhibits the findings of the study regarding the relationship between green buildings and the well-being in addition to environmental awareness of occupants. The use of colour coding allows for a clearer indication of commonalities and distinctions in the experiences of respondents. In the case of occupant well-being, the green colour suggests a reported improvement in well-being, the red colour indicates a deterioration in well-being, and the blue colour represents the absence of any impact on the well-being of the occupant since occupying the green building. In terms of environmental awareness, the green colour indicates a reported positive influence on environmental awareness and the red colour indicates the absence of any impact on the occupants' environmental awareness.

Relationship between green building and well-being and its impact on occupants' environmental awareness				
Respondent	Perceived well-being (positive/ negative/ neutral)			Environmental awareness
CS1R1[2]	Reported improvement in well-being			Positive influence on awareness and attitude
CS1R2[2]	Reported improvement in well-being			Positive influence on awareness and attitude
CS1R3[5]	Reported improvement in well-being			Positive influence on awareness and attitude
CS1R4[7]	Reported improvement in well-being			Positive influence on awareness and attitude
CS2R1[2]	Reported improvement in well-being			Positive influence on awareness and attitude
CS2R2[2]	Reported improvement in well-being			Positive influence on awareness and attitude
CS2R3[3]	Reported improvement in well-being			Positive influence on awareness and attitude
CS2R4[1]	Reported improvement in well-being			Positive influence on awareness and attitude
CS3R1[4]			Reported no noticeable impact	No impact on awareness and attitude
CS3R2[4]	Reported improvement in well-being			Positive influence on awareness and attitude
CS3R3[1]	Reported improvement in well-being			Positive influence on awareness and attitude
CS3R4[4]		Reported compromised well-being.		No impact on awareness and attitude

Table 4.7 – Cross case analysis table

4.4 Chapter Summary

This chapter sought to present a discussion of the findings from the series of interviews conducted with respondents from three Edge-certified social housing buildings using a multiple-case study approach. The findings allowed the researcher to identify and compare commonalities and distinctions across the different case studies using cross-case analysis. In Chapter 5, the results are checked against the available literature to establish whether the research findings support or contradict the claims made in the literature which allow for conclusions to be drawn and a discussion on future research to be presented.

Chapter 5: Conclusions and Recommendations

5.1 Introduction

This research aimed to study the relationship between green buildings and the well-being of their occupants as well as the impact that green buildings have on the environmental awareness of occupants. Chapter 5 refers to the research objectives that were set out in Chapter 1, which are then reviewed against the findings presented in Chapter 4 in order to support or refute the proposition. A conclusion is then drawn, which is followed by a discussion on the limitations of the study and recommendations for future research are suggested.

As outlined in Chapter 1, the research addresses the following problem statement:

Not much is known about the relationship between green low-cost social housing and the well-being of occupants as well as its impact on their environmental awareness.

The corresponding research question was:

What is the relationship between green low-cost social housing on the well-being of occupants and what impact does it have on their environmental awareness?

The proposition to be tested was:

A positive relationship exists between green low-cost social housing and the well-being and environmental awareness of occupants.

5.2 Achievement of Research Objectives

The research objectives for the study are listed as follows:

i. Establish what constitutes green social housing.

ii. Determine what constitutes occupant well-being.
iii. Determine the perception of occupants on the impact of green features implemented in their buildings on their well-being.
iv. Establish whether occupying green buildings influence the environmental awareness of occupants.

Objective (i), establishing what represents green social housing was achieved by reviewing the available literature on green buildings and referencing that against what was implemented on the buildings investigated. The literature provides various definitions for green buildings however, the general theme among the definitions is that green buildings are buildings that are environmentally considerate in their design and use of materials and technologies, promote good health and well-being of occupants and encourage sustainable development (Lee and Chen, 2008; Ashuri and Durmus-pedini, 2010; GBCSA, 2010; Shabrin and Kashem, 2017). The literature identifies key strategies for green buildings, these include site selection and building and orientation, design that encourages passive heating and cooling, natural ventilation and promotion of indoor environmental quality, the integration of natural green spaces in the design, and the implementation of energy-efficient technologies (Bowyer, 2007; Lee and Chen, 2008; GBCSA, 2010; Golubchikov and Badyina, 2012). The researcher conducted a site investigation and reviewed the available information on each building as it relates to aspects of the design, green features and technologies and this was checked against the literature as well as what green features and technologies the occupants were aware of and how they were affected by them.

Objective (ii), determining what constitutes occupant well-being, was achieved by reviewing the literature on well-being and understanding the various definition thereof. The literature revealed that the concept of well-being was linked to the quality of life, health and the emotional state of persons and that it was both subjective and relative (Ryan and Deci, 2001; McMahon, 2006; Bergdolt, 2008; Camfield and Skevington, 2008; McDowell, 2010). The relative and subjective nature of well-being required that the semi-structured interviews focus on the perceived well-being of respondents, this was accomplished by requesting respondents to define what well-being meant to them and what factors they thought contributed to their

well-being. The respondents provided concise answers on what well-being meant for them and the relevant contributing factors, as this information was then checked against their experiences since occupying their respective buildings to establish if a connection existed between green buildings and occupant well-being.

Objective (iii), determining the perception of occupants on the impact of green features implemented in their buildings on their well-being, was achieved through the analysis of the respondent's answers to the semi-structured interview questions. The respondents were questioned about their experiences in their previous places of residents, this information would enable them and the researcher to make a comparison between their past and current experiences. Respondents were then requested to provide their understanding of well-being and the factors that they felt contributed to their well-being. This allowed the researcher to have a specific set of matrices on which to analyse the respondents' experiences since moving into their respective green buildings. The exercise revealed a consensus among respondents that a noticeable improvement in their well-being was experienced since occupying the green buildings (Shabrin and Kashem, 2017; Lee *et al.*, 2019). While the response was mostly positive, two of the respondents expressed experiences that are contrary to the majority. The first respondent reported having experienced no noticeable change in their well-being, while the other reported experiencing an adverse impact on their well-being since moving into their building. The experience of the latter may be a result of a lack of information on how to effectively utilise the green features implemented in their building. The respondent reported having not been workshopped about the features and technologies of the building they occupied (Cole, 1999), and this may have led to the respondents' negative experience.

Objective (iv), establishing whether occupying green buildings influenced the environmental awareness of occupants, was achieved by questioning the respondents about their opinion on which they felt was more important between infrastructure development and environmental conservation. Milfont and Duckitt (2010) define environmental awareness as the psychological propensity that is expressed by assessing the natural environment either favourably or negatively. The responses revealed that the majority of respondents were aware of the challenges posed by development on the environment but were also aware of the importance

of development in the improvement of quality of life for people. A significant number of the responses indicated equal importance being placed on infrastructure development and environmental conservation and called for a balance between the two. The respondents were then asked if they felt that their perception and attitudes towards the environment had changed or been influenced by living in a green building.

The majority of the respondents reported that while they may have been aware of the issues affecting the environment and the need to act, living in a green building reinforced their commitment to the environment and encouraged them to identify ways in which they could contribute towards solving some of the challenges affecting the environment (Dunlap *et al.*, 2000). Only two of the respondents placed infrastructure development ahead of environmental conservation, arguing that job creation and economic development were contingent on infrastructure development.

Respondents were then asked about the actions they were taking to enhance and protect the environment. The literature suggests that environmental awareness is a genuine concern for the environment and a feeling of obligation to act to protect it (Chawla, 1998; Dunlap *et al.*, 2000). What was found was that although there were contrasting views regarding infrastructure development and environmental conservation, all respondents reported taking active steps towards improving and protecting the environment.

5.3 Findings of the Research Question

The study sought to address the following research question:

What is the relationship between green low-cost social housing on the well-being of occupants and what impact does it have on their environmental awareness?

The benefits of green buildings in the commercial sector and their effects on productivity have been extensively documented in the literature. However, limited studies have been conducted that focus on green buildings in a social housing context and the impact they have on the well-being and environmental awareness of occupants (Allen *et al.*, 2015; MacNaughton *et al.*, 2016). This study sought to contribute to the limited literature on the subject and the findings

suggest that occupants of social housing developments with green features experienced a noticeable improvement in their well-being and quality of life.

Respondents reported that the environment in and outside of the green buildings they occupied promoted their physical, psychological and financial well-being (Kaplan and Kaplan, 1989; Kellert and Wilson, 1993). In terms of the external environment, the findings suggest that green features implemented outside of the buildings such as natural gardens and green open spaces played a significant role in improving the psychological well-being of occupants. Respondents reported that access to these spaces brought about feelings of happiness and relaxation which confirms the findings by Ne'Eman (1974) and Boyce *et al.* (2003) that access to the natural environment improves well-being and psychological function.

Praag (2003) observed that well-being results from a person's satisfaction in their finance, home, health and environment. Similarly, Joo (1998) states that well-being is linked to an individual's perception of their financial status, living conditions and their ability to meet their needs. The study confirms these observations as several of the respondents reported that the savings on their energy bills enabled them to put more food on the table for their families and use the money for other household essentials. Furthermore, the feedback from respondents suggests that they consider financial wellness as a key contributor to psychological well-being. Several of the respondents reported experiencing an improvement in their psychological well-being as a result of being in a better financial position. Some of the recurring themes observed in the respondents' responses on the subject of financial well-being included, reduced stress and anxiety, improved sleep health and general well-being. This supports the suggestions by Chow (2020) and Pearlin *et al.* (1981) that a positive relationship exists between financial stress and anxiety which causes difficulties in sleeping.

In terms of the effect that green buildings have on the environmental awareness of occupants, the findings suggest that a connection exists between green buildings and the environmental awareness of occupants. The feedback from respondents indicates that a certain degree of influence on their outlook on environmental affairs occurred since occupying their respective buildings. Respondents reported experiencing a new or renewed sense of commitment to the environment and an obligation to act towards protecting or improving it since moving into the buildings. Initially, it was assumed that the degree of influence was a result of the induction that occupants underwent at the beginning of their tenure in the building where they were educated about the buildings they occupied and the role that green buildings play in ensuring

environmental sustainability. However, given that only half of the sample group underwent induction and yet over 80 per cent of the respondents reported being positively influenced suggests that while training played a crucial role, it is not the only determining factor. Other factors included the respondents' experiences living in the building as well as their life experiences.

5.4 Re-visiting the Research Proposition

The study aimed to address the following research proposition:

A positive relationship exists between green low-cost social housing and the well-being and environmental awareness of occupants.

The implementation of green building strategies in the design and construction of low-income social housing developments benefits the occupants not only in terms of providing them with housing opportunities but creates an environment in which their well-being is promoted and in turn, their awareness and willingness to act towards protecting the environment is encouraged.

The findings of this study support the research proposition, given that respondents reported experiencing improvements in their well-being and a noticeable change in their environmental awareness since taking occupation of their respective green buildings. It should be noted that whilst not all of the respondents reported experiencing an impact in these two areas, the majority of the response was positive.

5.5 Conclusions

Climate change and economic challenges have intensified global efforts to accelerate the adoption of green building for sustainable development and the reduction of poverty through efficient uses of energy, protection of ecosystems and preservation of natural resources. In South Africa, challenges such as water shortages, consistent load-shedding and extreme weather temperatures have put pressure on the building sector to adopt and implement green

building practices (Simpeh, 2018b). However, the country's adoption of green building practices in the social housing sector is still in its infancy, this is confirmed by the limited number of social housing developments with green certification.

In the commercial sector, the benefits of green building are largely concerned with the bottom line, which is profit that is driven by productivity. However, these indicators do not apply in the provision of low-cost social housing as the primary objective is not to make a profit instead, it is to improve the welfare of the beneficiaries (Sowman and Urquhart, 1998). Additionally, in working towards meeting some of the country's sustainable development goals it is important to create environments that foster attitudes of environmental awareness and concern in people. It is in this context that the importance of studies that investigate the well-being and environmental awareness of occupants becomes apparent as they provide a non-monetary indicator with which government and private sector investors can measure the performance of their investment.

The findings from this study indicate that the integration of green building practices in the provision of low-cost social housing developments positively impacts the well-being and environmental awareness of occupants.

5.6 Recommendations for Further Research

(i) Investigate standardised tools for measuring occupant well-being in green residential buildings.

As indicated in the literature, well-being is both subjective and relative and therefore the calculation thereof remains a challenge (McMahon, 2006; Bergdolt, 2008; McDowell, 2010). Currently, the performance calculation of green residential buildings is limited to the physical structures and not the people that occupy them. The development of a standardised tool for measuring well-being in green buildings will complement the existing tools for measuring building performance and thus, provide data that is more accurate and comprehensive.

(ii) Include a wider range of income groups.

This study was limited to low-cost social housing. A recommendation for future research would be to study the relationship between green buildings and the well-being of social housing beneficiaries in higher-income groups.

(iii) Increase the number of green social housing developments that are investigated.

As previously mentioned, a limited number of green-rated social housing developments currently exist in South Africa. However, the number of certifications increases with each passing year and this allows for future research to have access to greater sample sizes from which to draw comparisons.

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List of Appendices

Appendix 1: Interview Transcript

Interview with respondent: CS1R4[7]

Researcher: How long have you stayed in the complex?

Respondent: Close to seven years now, I am one of the earlier residents of the complex.

Researcher: Where did you reside before moving into the complex?

Respondent: I moved around for a while after moving out of our family house to look for a place of my own. At some point, I lost my job and could not afford to pay rent so I moved into a shelter, then when I found employment and things got better I moved out of the shelter and rented an RDP house. I think that there is a law against people renting out or selling RDP houses but I was not really concerned about that at the time. I needed a place to stay and that house offered a temporary solution. I say temporary because, after almost 3 years of staying there, I was forced out as the owner had found a buyer for the house.

Researcher: Are you familiar with the concept of green building?

Respondent: I have a basic idea of what green building is. I think green buildings are buildings that make efficient use of the environment. Things such as harvesting rainwater, using solar panels and so on.

Researcher: Do you know that this building is a green building?

Respondent: Now I do. I found that out when I applied and attended the workshop where they discussed the features of the building.

Researcher: Did the fact that this is a green building influence your decision to want to come to stay in this building?

Respondent: No, when I moved here I was desperate for a place to stay. So even if it wasn't a green building I would have been happy to just have a place to stay.

Researcher: How would you describe your spending on electricity before moving into the building?

Respondent: Things were rough, I used to spend about a quarter of my salary on electricity. That might not seem like a lot for some people but you have to remember that I did not earn much so having to spend a large portion of my income on electricity was really cutting away at my livelihood. I was living from pay cheque to pay cheque so keeping the electricity on was a big struggle for me, sometimes I would go without electricity because I had to prioritise other things with the money needed to purchase electricity.

Researcher: Have you ever been unable to settle your municipal electricity account, been disconnected due to non-payment or been unable to purchase pre-paid electricity?

Respondent: Yes, many times, both in the RDP that I rented and back when I stayed with my siblings before finding my own place. What made things worse was that the house we used to stay in was my parent's house, which we inherited. But we also inherited the utility debt that my parents were unable to pay. So when they passed, all that debt fell into my hands and it took a long time to settle that account. When I moved into the RDP I still had to assist my siblings back home so you can imagine struggling with keeping myself afloat while still having to provide for another household was not easy. The RDP had a prepaid meter box so I was never disconnected but I have spent many times in the dark because of the electricity not lasting and not having the money to purchase more. It also had a solar geyser but during my stay there I do not recall it working even a single time, so I used to boil water in the kettle for bathing. I can count on one hand the number of times I bathed with warm water. The rest of the time I only used cold water just to keep the lights on for longer. I had a heater that I thought would come in handy during the winter but I used it only once and realised how much electricity I was wasting. The winters were unbearable but I had to push through, I eventually bought myself a paraffin heater which solved the problem of being cold but created a new health problem for me because of the fumes, I constantly suffered from headaches. You know, living like that is what makes people resort to doing illegal connections and I would be dishonest to you if I said the thought never crossed my mind.

Researcher: Would you say the incident described above caused or contributed to your stress?

Respondent: A lot, that was a very difficult time for me. I did not have a stable and well-paying job. It was an extremely difficult and stressful time for me, so much so that I can only thank God for being alive today because I was not well both emotionally and physically, it was bad.

Researcher: Have you experienced a similar incident since moving into the building?

Respondent: No, I would say I have been quite fortunate to not have had a repeat of my past experiences. Life here has been good, that is one of the reasons I do not think I would want to leave this place but at some point I know I will have to.

Researcher: Why is that?

Respondent: I do not think this place is meant to be a long-term home for people, I think it is designed to help people get on their feet by creating an environment that makes it possible to get your head on straight while also saving money so that one day you can go out and build a life for yourself because at that point you would be financially secure and prepared mentally. By so doing, you would be providing the same opportunities that you have experienced to the next person that might be in a desperate situation.

Researcher: Have you experienced a reduction in your electricity expenses since moving into the building?

Respondent: Most definitely, we spend much less on electricity and overall household expenses. On average I expect to spend around two hundred rands on electricity for my place here.

Researcher: How would you describe the significance of the reduction?

Respondent: There is a huge reduction in my electricity spending, the same applies to water. The heating system that we have here saves us a lot of money because it is pay-as-you-use, meaning you are required to only pay for the amount of hot water that you use and that makes it very economical. The showers and taps have some sort of mechanism that limits the amount of water that comes out, I think by reducing the pressure but it prevents you from using more than you need to, which reduces the bill at the end of the month. So for electricity, we went from paying over a thousand rands to paying a little over two hundred rands is a big difference. I can put more food on the table for my family. I can make sure that we have all of what we need.

Researcher: What is your definition of well-being and what do you think contributes to your well-being?

Respondent: For me, is being happy, healthy and comfortable, and I think the things that contribute to that are good psychological, social, emotional, financial and spiritual well-being.

Researcher: How would you describe the environment inside your flat and do you think it has any impact on your well-being?

Respondent: The flat never feels stuffy or uncomfortably warm during the night so sleeping is not a challenge for me. If I ever struggle to sleep it is because of work stress but I eventually fall asleep and I wake up feeling rested and ready to go and tackle whatever challenge I am facing at work that is stressing me. So the flat is comfortable and homely, I can stay indoors during the day with just the windows open, there is no need for an air conditioner or fan and at night I sleep soundly and peacefully.

Researcher: How would you describe your overall well-being or quality of life since moving into the building?

Respondent: I would say my well-being has improved a lot since moving here, I live a good life now. And I know that might not mean much coming from a person that was almost homeless and ended up in a shelter at some point but yes, I have experienced the lowest of lows

and this right now is a high point in my life. I have my family with me and I am able to clothe them and put more food on the table. I have no stress or anxiety about waking up tomorrow and not having money for food or electricity so I sleep better. I have enough left over from the little that I make so I can afford other household essentials.

Researcher: Do you think that as people we have a responsibility to protect the environment even if it is at the cost of development?

Respondent: That was what God said to Adam and Eve at the very beginning. He said you will tend to the garden, look after my creation. Meaning as people, we need to take care of our environment and the planet as a whole as this was an instruction from God. So while it is important to build houses and provide places for people to live, it is also important to think about future generations. We should not be wasteful.

Researcher: Would you say staying in a green building has influenced your attitude towards the conservation of the environment?

Respondent: I think the answer that I gave to the previous question shows that I am very environmentally conscious. But I did not hold that view before moving here, it is only after I learned about what green buildings are and what role they play for the environment did I began to care more about the environment. So yes, staying in this building has influenced my view on the importance of protecting the environment and not just for us but for our children and their children long after we have passed.

Researcher: What actions are you actively taking to play your part in the conservation of the environment?

Respondent: I am a huge advocate for recycling and reusing. These are small things but I think it is a step in the right direction.

Appendix 2: Confirmation of Ethics Clearance

Application for Approval of Ethics in Research (EiR) Projects
Faculty of Engineering and the Built Environment, University of Cape Town

ETHICS APPLICATION FORM

Please Note:
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the **EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant		Lwazi Zulu
Department		Department of Construction Economics and Management
Preferred email address of applicant:		zlxlwa005@myuct.ac.za
If Student	Your Degree: e.g., MSc, PhD, etc.	MSc. Project Management
	Credit Value of Research: e.g., 60/120/180/360 etc.	60
	Name of Supervisor (if supervised):	Saul Nurick
If this is a researchcontract, indicate the source of funding/sponsorship		N/A
Project Title		A study into the improvement in quality of life for occupants of green low-cost social housing and the relationship between green building and environmental awareness

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

APPLICATION BY	Full name	Signature	Date
Principal Researcher/ Student/External applicant	Lwazi Zulu		17.05.2022
SUPPORTED BY	Full name	Signature	Date
Supervisor (where applicable)	Saul Nurick		17.05.2022

APPROVED BY	Full name	Signature	Date
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section 1; and for all Undergraduate research (Including Honours).	Dr. Frank K. Ametefe		2022/06/08
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the questions in Section 1.			