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2023

University of the Witwatersrand, Johannesburg

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Katumba, Bamoni Nathalie. (2023). Assessing the Retrofitting of Office Buildings in the City of Johannesburg, South Africa [Master's dissertation, University of the Witwatersrand, Johannesburg]. WireDSpace.https://hdl.handle.net/10539/40407

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Assessing the Retrofitting of Office Buildings in the City of Johannesburg, South Africa

by

Bamoni Nathalie Katumba

2513148

A research article submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration

Protocol number: (WBS/BA2513148/995)

Johannesburg, 2023

Classification - Public

DECLARATION

I, Bamoni Nathalie Katumba, declare that this research dissertation is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.



(Bamoni Nathalie Katumba)

Signed at Lyndhurst

On the 30th day of May 2023

DEDICATION

I dedicate this research report to God Almighty, my provider, my strong tower, and my pillar of strength. And I also dedicate this research report to my three sons, Baraka, Emmanuel, and Jayden Katumba. Mommy loves you to the moon and back.

Nelson Mandela once said, “It always seems impossible until it is done.”

ACKNOWLEDGEMENTS

This research would not have been possible without the support and guidance of many people who contributed directly or indirectly to the preparation and finalisation of this report:

- To Professor Diane Hildebrandt and Dr Bryce Young, thank you for your guidance, knowledge and our weekly meetings with the research teammates.

- My gratitude to MMQSMace for sponsoring my studies. To my mentor and Director at MMQSMace, Mandla Mlangeni, thank you for your leadership.

- To my parents and role models, Emmanuel Badibanga and Petronie Kabanga, for their unconditional love, prayers, unwavering support, guidance, and encouragement during my studies.

- To my husband, Billy Katumba, for his love, prayers, and sacrifices. And my children, Baraka, Emmanuel, and Jayden Katumba (my inspectors), for their understanding and patience during my studies.

- And finally, to all my siblings, extended family, friends, colleagues, report editors, research respondents and MBA classmates, thank you for all your support.

SUPPLEMENTARY INFORMATION

Nominated journal: Energy and Buildings. (n.d.)

Supervisor / Co-author: Professor Diane Hildebrandt / Dr Bruce Young

Word count †:13 824

Supplementary files: Survey Questionnaires

Statistical analysis Descriptive statistics and t-test

References

ABSTRACT

Climate change caused by greenhouse gasses (GHG) has become a challenge to the world and South Africa (SA) alike. SA emits 450 million tons per annum (TPA) of carbon dioxide (CO_2) and is the 12th largest CO_2 emitter in the world. Buildings account for 50% of GHG, globally; therefore, energy use in new and existing buildings must be addressed. Retrofitting existing buildings has been identified as one of the ways to achieve sustainability in the built environment, this is done by enhancing energy efficiency (EE), the environmental performance of the property and lowering energy demand. This study, therefore, examined the challenges, benefits and critical success factors (CSF) for retrofitting offices in the City of Johannesburg (CoJ), SA. The data for this study were obtained from built environment professionals with experience in retrofitting existing office buildings. An online questionnaire was issued to the targeted sample using Google Forms and 71 responses were received. The quantitative data were analysed using the t-test function from the Statistical Package for Social Sciences (SPSS) software. This study uncovered that lack of government incentives; budget constraints; longer payback periods; technical challenges and disruption of and inconvenience to the tenant during retrofitting are the top five challenges hindering retrofitting of existing office buildings. The study also identified improved EE; enhanced marketability of the buildings; improved building climate control; reduced energy consumption and reduced operational cost of buildings as the top five benefits of retrofitting existing office buildings. Furthermore, project cost control; communication; efficient planning and regulatory approvals between the municipality and project manager; project schedule management and competency of the project manager were revealed as the top five CSF that influence retrofitting of existing office buildings. Recommendations include engagements between various stakeholders; cost benefits analysis; CSF at the beginning of retrofitting projects; changes in government regulations and policies to incentivise retrofitting projects; tenants' inputs throughout projects, public and private sectors collaboration; availability of retrofitting information and inclusion of sustainability in the built environment tertiary curriculum.

Keywords: Retrofitting, Sustainability, Existing office buildings, Challenges, Benefits, Critical success factors, Johannesburg.

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LIST OF ABBREVIATIONS

Abbreviation	Description
A	Agree
BA	Bachelor's Degree
CO2	Carbon Dioxide
CoJ	City of Johannesburg
CCI	Clinton Climate Initiative
CSF	Critical Success Factors
CS	Corporate Sustainability
CSR	Corporate Social Responsibility
D	Disagree
EE	Energy Efficiency
EERE	Energy Efficiency and Renewable Energy
GBR	Green Building Retrofit
GHG	Greenhouse Gasses
Hons	Honours Degree
HVAC	Heating, Ventilation & Air Conditioning
M	Master's Degree
MBA	Masters of Business Administration
N	Neutral
PhD	Doctor of Philosophy
RII	Relative Importance Index
RO	Research Objective
ROI	Return on Investment
SA	South Africa
SAg	Strongly Agree
SA-LEDS	South Africa's Low-Emission Development Strategy
SD	Standard Deviation
SDi	Strongly Disagree
SEAI	Sustainable Energy Authority of Ireland
SPSS	Statistical Package for Social Sciences
TPA	Tons Per Annum
UNEP	United Nations Environment Programme
US	United States
USGBC	United States Green Building Council

CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION AND BACKGROUND

The City of Johannesburg (hereafter CoJ) dates back to 1886 and is identified as “eGoli” meaning “place of gold” in isiZulu. The city started as a camp for miners and quickly became a large economic metropolis during apartheid, with the construction of tall buildings and skyscrapers. Since mining was the main economic activity, CoJ attracted migrant labours seeking better economic opportunities (Beavon 2004; Garner 2010; Murray 2011; Iqani & Baro, 2017 as cited by Baro, 2020). South Africa’s Low-Emission Development Strategy (SA-LEDS) (2020) posits that of all greenhouse gasses (GHG) across sectors in South Africa (SA), energy-related emission accounts for the largest share (79%), with electricity generation accounting for more than 50% of emissions from the energy sector (Environment.gov.za, 2020). There is, therefore, a need to address the energy use in new and existing buildings. According to Olarenwaju and Mbohwa (2017), to protect our future, ways of alleviating GHG must be developed. Figus *et al.* (2017) opine that there are positive impacts from energy efficiency (EE) retrofits, including the capacity to reduce GHG, as well as a wide range of economic benefits at all levels. However, despite the benefits associated with retrofitting buildings, Clinch and Healy (2000) stated that there are several barriers. These include climate, services, human behaviour and government policy changes, amongst others (Ma *et al.*, 2012, as quoted by Duran, 2018). These constraints and barriers must be dealt with if success is to be achieved in retrofitting buildings. Husin *et al.* (2019) identified that stakeholders are too focused on constructing new green buildings to combat climate change and are disregarding existing buildings. The authors identified retrofitting existing buildings as a key driver to reducing energy utilisation and enhancing EE in Malaysia in the short term, as new building construction will take longer to implement and will require more resources before the impact of sustainability is realised (Husin *et al.*, 2019).

Due to the importance of retrofitting buildings, as well as SA’s goal to meet and exceed its carbon emissions reduction target by a substantial margin, it is paramount that retrofitting solutions are adopted. To bridge this gap, it is therefore important to assess the retrofitting of existing commercial buildings in the CoJ to decarbonise the environment and safeguard the future.

1.2 CONTEXT OF STUDY

According to the article *Why the Building Sector?* (Architecture2030, n.d), 40% of annual global Carbon Dioxide (CO_2) emissions are generated by the built environment. Per annum, 27% is attributed to building operations and 13% to embodied carbon - which includes the material and construction sector (Architecture2030, n.d). Zavadskas et al. (2008) stated that retrofitting an existing building should not be viewed as an energy consumption reduction only but rather as an enhancement of the building's lifespan and market value. The Authors recommended that various retrofit scenarios be developed and assessed from different perspectives. The choice, therefore, should depend on long-term urban strategy, condition of the building and the environment, costs of renovation, energy saving and future market value of the building.

1.3 PROBLEM STATEMENT

It has been established that GHG have a significant negative impact on the climate, globally. Buildings, which are products of the construction industry, contribute significantly to the total GHG emitted (SA-LEDS, 2020). Enshassi *et al.* (2014) identify some impacts of construction on the environment, such as resource depletion and waste generation. Duran (2018) posited that retrofitting buildings has the main advantage of reducing operational energy and carbon emissions. According to Al-Kodmany (2014), the United States Green Building Council (USGBC) defined retrofitting as:

> *…any kind of upgrade at an existing building that is wholly or partially occupied to improve energy and environmental performance, reduce water use and improve the comfort and quality of the space in terms of natural light, air quality and noise.*

As stated by Assefa and Ambler (2017), Green Building Retrofit (GBR) offers the possibility of reusing a building structure, reducing maintenance costs and reducing the volume of construction waste. However, GBR has been identified as a complex process and as a result, there are several challenges facing the concept (Clinch & Healy, 2000). Furthermore, the lack of skilled personnel and professionals with knowledge of retrofitting proves that the concept - which aims at improved building performance - is still in its infancy in SA (Okorafor *et al.*, 2021). For the objectives of this study, the retrofitting definition by the USGBC will be adopted.

The elements, including challenges, benefits and critical success factors (hereafter CSF) influencing the retrofitting of existing office buildings in the CoJ have not been widely researched, hence the impact eludes stakeholders. Therefore, there is a need to investigate the elements that affect the retrofitting of an existing office building in CoJ.

1.4 RESEARCH AIM

The study aims to evaluate aspects influencing the retrofitting of an existing office building in the CoJ. This evaluation includes the difficulties and advantages, as well as CSF involved in retrofitting.

1.5 MAIN RESEARCH QUESTION

What elements, including challenges, benefits and CSF, affect the retrofitting of an existing office building in the CoJ?

1.6 RESEARCH SUB QUESTIONS

In assessing the retrofitting of office buildings in the CoJ, SA, the following questions must be answered:

i. Are there challenges of retrofitting existing office buildings in CoJ?
ii. Are there benefits of retrofitting existing office buildings in CoJ?
iii. Are there CSF for retrofitting office buildings in CoJ?

1.7 RESEARCH OBJECTIVES

The objectives of this study are to:

i. Examine the challenges of retrofitting existing office buildings in CoJ.
ii. Evaluate the benefits of retrofitting existing office buildings in CoJ.
iii. Assess the CSF for retrofitting existing office buildings in CoJ.

In achieving the research objectives (ROs), the nature of the ROs, as well as the research strategy are considered. The research strategy is elaborated on in the methodology chapter. The three ROs of the study require hypotheses to be tested to achieve the envisaged outcome, as the research uses a survey strategy to obtain quantitative data. Hence, there is a need for a corresponding hypothesis for each of the ROs. RO3 will be further analysed

using the relative importance index (RII) to assess and rank the CSF for retrofitting office buildings in CoJ.

1.8 RESEARCH HYPOTHESES

The different research hypotheses, which mirror the research sub-questions are presented in the null and alternate hypothesis forms:

H_{01}: There are no challenges with retrofitting existing office buildings in CoJ.

H_{A1}: There are challenges with retrofitting existing office buildings in CoJ

H_{02}: There are no benefits to retrofitting existing office buildings in the CoJ.

H_{A2}: There are benefits to retrofitting existing office buildings in the CoJ.

H_{03}: There are no CSF for retrofitting office buildings in the CoJ.

H_{A3}: There are CSF for retrofitting office buildings in the CoJ.

1.9 RATIONALE OF THE STUDY

SA has been identified as one of the leading emitters of GHG and accounts for 65% of GHG in Africa (SA, 2013 as cited by Tongwane *et al.*, 2016). The country emits 450 million tons per annum (TPA) of CO_2, the 12^{th} largest CO_2 emitter in the world (Ritchie, 2020). The rate of gas emission, which is generally from electricity generation, has continued to grow over the years. This situation can be linked to the continuous growth of the construction industry in SA. People spend most of their time and activities in buildings, thus comfort is important to their well-being, health, general pleasure and productivity (Nematchoua *et al.*, 2014). However, in other to protect our future, the current trend of GHG - particularly from the built environment - must not be allowed to continue. Hence, this study will assess retrofitting of office buildings in CoJ as a means of mitigating GHG.

The impact of this study is to promote knowledge and expertise regarding retrofitting existing office buildings within the CoJ. The study intends to assess factors affecting retrofitting of existing office buildings in the CoJ, including challenges, benefits and CSF related to retrofitting.

1.10 OVERVIEW OF CHAPTER

The study is divided into several chapters. The first chapter, **Chapter One: Introduction,** provided an overview and background of the study. It clearly stated the research aims questions, objectives and hypotheses, the study's rationale, as well as outlined the course of actions necessary to complete the study.

Chapter Two: Literature Review reviews extant literature by other authors related to the study and details the findings of retrofitting existing office buildings. Thereafter, **Chapter Three: Research Methodology** describes the rationale of the study, the methods adopted to determine who the respondents would be and the data collection method. It describes the data sample, data source and data collection instruments. It also conveys the method of data analysis intending to achieve the study ROs. In addition, this chapter discusses the reliability and validity of the data and ethical considerations employed for this study.

Chapter Four: Data Analysis highlights the collected data, the statistical analysis done based on collected data and its results. The chapter firstly analyses the background information of respondents and secondly ranks factors affecting challenges of, benefits of and CSF influencing retrofitting of existing office buildings using Statistical Package of Social Science (SPSS) software.

Chapter Five: Discussion of Findings discusses the study findings of the previous chapter and compares them with the reviewed literature in fulfilling the ROs. The study ROs stand i) to examine the challenges of retrofitting office buildings in the CoJ; ii) to evaluate the benefits of retrofitting office buildings in the CoJ; and iii) to assess the CSF for retrofitting office buildings in the CoJ. These may either contradict or corroborate existing literature. Finally, **Chapter Six: Conclusion and Recommendation** highlights the main conclusions and limitations based on the findings and includes recommendations for further studies.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter begins with an introduction and provides background information on the research topic. The chapter reviews existing literature regarding challenges, benefits and CSF of retrofitting existing office buildings and views from various authors in line with the current study. The first section of the literature covers background information on this study, followed by the second section that includes a review of the literature and incorporates the impacts on the environment caused by construction activities, the development of sustainable construction and an overview of retrofitting. The third section covers the significance of the literature review, the fourth section covers the theoretical framework, the fifth section covers the conceptual framework and lastly the sixth section provides a conclusion to the chapter.

2.2 BACKGROUND

In SA, the concept of retrofitting is still in its early stages; this suggestion is based on the lack of delivery systems, lack of rates benchmark, limited knowledge by the builders and professional teams and inadequate data on retrofitting projects (Okorafor, 2019). This study seeks to evaluate aspects influencing the retrofitting of an existing office building in CoJ, including the difficulties and advantages, as well as the CSF involved in retrofitting.

2.3 LITERATURE REVIEW

This section includes a review of literature outlined in three sub-sections, these are (1) construction activities' impact on the environment followed by (2) sustainable construction and an overview of retrofitting including, challenges, benefits, and CSF of building retrofitting.

2.3.1 Construction activities' impact on the environment

According to Erlandsson and Levin (2005), the world only recently became aware of the negative implications of construction activities, which have rapidly utilised environmental resources for economic growth since the industrial revolution. Enshassi *et al.* (2014) identified some impacts of construction on the environment, such as resource depletion and waste generation. European Union Commission (EU) corroborated this point by claiming that about

50% of all materials extracted are construction sector related, while also generating 35% of its total waste. This is also the case in developing countries like South Africa, where the construction industry generates a substantial part of the greenhouse gas emitted in the country, with 18 metric tonnes of carbon dioxide emitted annually in the production of construction materials (Simpeh and Smallwood, 2018).

2.3.2 Sustainable construction

According to Charef *et al.* (2021), the end-of-life phase of a project is the least sustainable, considering the extent of waste being produced by a demolition procedure. Geltner *et al.* (2017), therefore, claim that major renovation projects that involve retrofitting commercial buildings are key to sustainability in the built environment for developed countries such as the United States (US). Office buildings consume the bulk of resources and energy including greenhouse emissions around the world; thus, retrofitting is a plausible idea in terms of value enhancement and reducing property price instability (Geltner *et al.*, 2017).

As per Jagarajan *et al.* (2016), green building retrofit (GBR) is a reasonable resolution to reduce the impact on the environment as buildings characterise approximately 50% of yearly energy and GHG. Retrofitting existing buildings is one of the ways to achieve sustainability in the built environment, by enhancing EE, enhancing the environmental performance of the property and reducing energy demand. Through retrofitting, history and culture can be preserved whilst a building can be made safe for the occupants and its life span can be extended (Jagarajan *et al.*, 2016).

2.3.3 Overview of retrofitting

Jagarajan *et al.* (2017, p.1361) cited the definition of retrofit projects by Sanvido and Riggs as:

> *The modification or conversion (not a complete replacement) of an existing process, facility, or structure. Such modification may involve additions, deletions, rearrangements, or replacements of one or more parts of the facility. Changes may alter the kind, quantity, cost or quality of the products or services being produced by the facility.*

The *Retrofit 2050* project by Eames *et al.* (2014, p.2) defined “sustainable urban retrofitting as the directed alteration of the fabric, form or systems that comprise the built environment

to improve energy, water and waste efficiencies". This study will adopt the model developed by Jagarajan *et al.* (2016) known as the 'Onion model' (Figure 1). This model is relevant to the study as it integrates and links CSF from GBR to sustainability and facilities management.

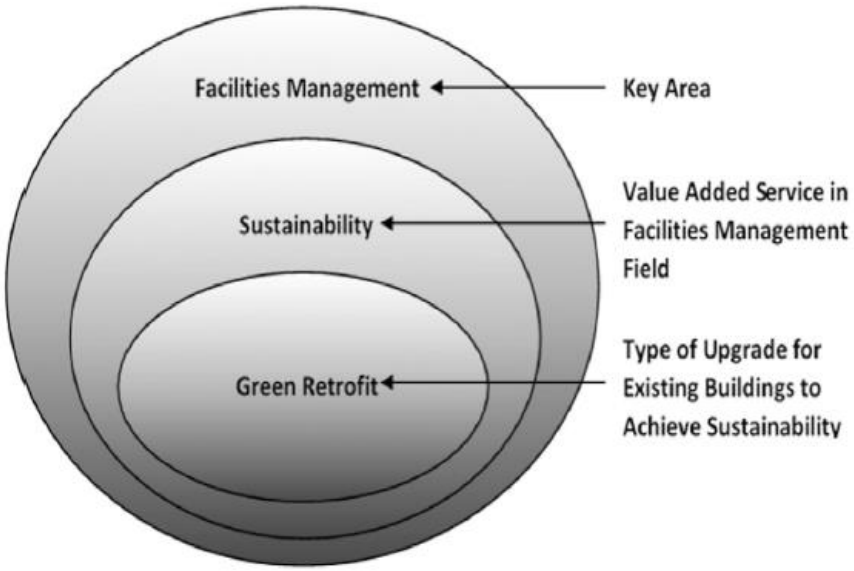


Figure 1: Onion model (Adapted from Jagarajan et al., 2016)

2.3.3.1 Challenges to building retrofitting

Dixon and Eames (2013) discuss the various obstacles to retrofitting in several parts of the world. According to a survey and interviews performed in China, the primary motive against the wide use of resource-saving technologies is due to people's resistance to adaptation (Du *et al.*, 2019). Jagarajan *et al.* (2016) identified challenges in GBR such as unpredictability and hurdles in terms of government regulations, global warming, budget constraints, longer payback period, operations disruptions and constraints, lack of government incentives to support owners, and 'split incentives' - whereby the owners are investing and funding the retrofit projects for tenants' benefit. In their research, Al-Kodmany (2014) identified 11 challenges regarding GBR. These are:

- Cost-effectiveness;
- Financial;
- Policies and codes;
- Split incentives;

- Technical challenges;
- Tenants;
- Operation and management;
- No one template;
- Historic buildings;
- Conducting retrofit around tenants' operations; and
- Security.

Additionally, Jagarajan *et al.* (2017) identified eight challenges in building retrofitting:

- Financial resources;
- Green building professionals;
- Policy support;
- Green development quantification;
- Green awareness;
- Communication;
- Internal leadership; and
- Green material and technology.

According to Ma *et al.* (2012) as quoted by Duran (2018), retrofitting existing buildings presents many challenges and opportunities. The major challenge involves uncertainties, such as climate change, services change, human behaviour changes and government policy changes, all of which directly affect the retrofit decisions. Furthermore, financial constraints, business disruptions and scheduling limitations are extra challenges that render the decision to retrofit difficult. Alfaiz *et al.* (2021) found that the lack of government legislation, lack of awareness about the benefits of GBR, lack of investment, the inexperience of the project team and lack of knowledge in sustainability were the five main challenges hindering the implementation of GBR in Iraq. In their study, Remøy and van der Voordt (2014) identified push and pull factors that companies consider before deciding whether to relocate or not. Factors such as lack of space, convenience, and location are considered crucial push factors that motivate tenants to relocate. Table 1 below is a summary of the challenges faced by stakeholders in the considerations for retrofitting.

Table 1: Challenges faced by stakeholders

No.	Challenges	References
1	Government regulations	Al-Kodmany, 2014; Bohlmann *et al.*, 2016; Jagarajan *et al.*, 2016; Jagarajan *et al.;* 2017; Ampratwum & Duah, 2019; Li, Liu, Tan & Zhang, 2020
2	Budget constraints	Miller & Buys, 2011; Al-Kodmany, 2014; Jagarajan *et al.*, 2016; Jagarajan *et al.,* 2017; Alam *et al.*, 2018; Terblanche, 2019
3	Longer payback period	Jagarajan *et al.*, 2016
4	Disruption of and inconvenience to the tenant during retrofitting	Al-Kodmany, 2014; Jagarajan *et al.*, 2016
5	Lack of government incentives to support owners	Jagarajan *et al.*, 2016; Lueng, 2018; Cheng *et al.,* 2019
6	Technical challenges	Al-Kodmany, 2014
7	No one template (Lack of benchmarking for office retrofitting)	Al-Kodmany, 2014
8	Lack of database for retrofitting information	Chang *et al.,* 2015; Ampratwum *et al.,* 2019
9	Demand for sustainable retrofitting buildings (Lack of demand for sustainable office buildings)	Miller & Buys, 2011
10	Uncertainty on return on investment (ROI)	Marquez, McGregor & Syme 2012; Li *et al.,* 2020
11	The building space is too small and tenants would rather relocate	Remøy & van der Voordt, 2014
12	Lack of government incentives	Li *et al.,* 2020
13	Conducting retrofit around tenants' operations	Al-Kodmany, 2014
14	Green building professionals (Lack of professional team expertise)	Opoku & Ahmed, 2015; Jagarajan *et al.,* 2017;
15	Split incentives	Jagarajan *et al.*, 2016; Al-Kodmany, 2014

Source: Author's own

2.3.3.2 Benefits of building retrofitting

Jagarajan *et al.* (2017) identified the benefits of conducting GBR such as enhancement of energy proficiency, improved employee efficiencies, cost preservation benefits and improved thermal comfort. In addition, retrofitting can improve the state's energy security and business community accountability, create job opportunities, decrease energy consumption and provide better livelihoods for the citizens. The advantages of retrofitting can be viewed at a triple bottom line level in terms of ***economic*** (GBR is more economical and shorter to undertake compared to new build and increase building value), ***environmental*** (less material waste, energy consumptions, pollution, resources during construction) and ***social*** (history and culture are preserved through retrofit). Duran (2018) identified that retrofitting for buildings has the main advantage of reducing 'operational energy requirements and carbon emissions' in addition to the communal, environmental and commercial status. In return, the enhancement of the office environment in terms of comfort, thermal and look can be linked to the end users' efficiency.

According to Mohd-Rahim *et al.* (2017), existing building retrofit can be more profitable compared to building new green infrastructure. Various analyses are required to be done to establish a suitable retrofit strategy and a return-on-investment analysis should be done in line with benchmark and other available comparable data. The authors identified four main factors to be considered as part of the retrofitting process for successful implementation, namely improvement of EE; change in technology; organisational structure importance and challenges; and behavioural change. Power (2008), as cited by Gohardani and Björk (2012), supported the view that there are important economic, social and environmental advantages of refurbishing a building as opposed to demolishing it. The advantages identified include reduction of resource utilisation, reduction of transport costs, preservation of community infrastructure, improvement of livelihood and local trade and industry development. The author further identified disadvantages, such as high initial investment cost.

Rughooputh *et al.* (2014) highlighted the benefits of sustainable buildings concerning traditional buildings in triple bottom lines:

- Environmental: Waste reduction, protection and rehabilitation of natural resources; enhancement of air and water property;

- Economic: Operating cost savings, enhance of tenants' productivity and gratification, life cycle performance optimisation; asset value improvement; and
- Social benefits: Improvement of tenants' wellbeing, improvement of livelihood, enhancement of air, thermal, sound atmosphere, reduce the burden on local infrastructure.

Assefa and Ambler (2017) as cited by Duran (2018), recorded the advantages of retrofits being both ecological and commercial in terms of reusing existing building structure and infrastructure; decreasing the quantum of material waste during construction; saving on the overall construction period; quick project turnaround to enable the building to resume operations. Other authors such as Ebbert (2010) have identified socio-cultural advantages of retrofitting in terms of heritage preservation and architectural value for the community.

Zavadskas *et al.* (2008) supported that retrofitting existing buildings is not only about decreasing energy expenditure but rather enhancing the structure of the building whilst extending its life span. Al-Kodmany (2014) supported the view that GBR extends the life span of the building and is a cost-effective development method compared to demolishing or acquiring buildings. According to Duran (2018), the retrofitting strategy is crucial to ensure full use of these benefits. Table 2 below is a summary of the benefits of GBR as captured in the literature.

Table 2: Benefits of GBR

No.	Benefits of GBR	References
1	Enhancement of energy proficiency	Jagarajan *et al.*, 2017; Duran, 2018
2	Improved employees efficiencies	Jagarajan *et al.*, 2017
3	Cost preservation benefits	Jagarajan *et al.*, 2017
4	Improved thermal comfort	Jagarajan *et al.*, 2017; Duran, 2018
5	Retrofitting can improve a state's energy security	Jagarajan *et al.*, 2017
6	Business community accountability	Jagarajan *et al.*, 2017
7	Create job opportunities	Jagarajan *et al.*, 2017
8	Decrease energy consumption	Jagarajan *et al.*, 2017
9	Provide better livelihoods for the citizens	Jagarajan *et al.*, 2017

10	Economic (GBR is more economical and shorter to undertake compared to new build and increases building value)	Gohardani & Björk, 2012; Rughooputh *et al.*, 2014; Jagarajan *et al.*, 2017
11	Environmental (less material waste, energy consumption, pollution, resources during construction)	Gohardani & Björk, 2012; Rughooputh *et al.*, 2014; Jagarajan *et al.,* 2017
12	Social (history and culture are preserved through retrofit)	Ebbert, 2010; Gohardani & Björk, 2012; Rughooputh *et al.*, 2014; Jagarajan *et al.,* 2017
13	Reduce resources utilisation	Gohardani & Björk, 2012
14	Reduce transport cost	Gohardani & Björk, 2012
15	Preservation of community infrastructure	Gohardani & Björk, 2012
16	Improvement of livelihood	Gohardani & Björk, 2012

Source: Author's own

2.3.3.3 Critical Success Factors of building retrofitting

According to Bu *et al.* (2015), considerations of GBR can be classified from three triangles/perspectives: i) Project management; ii) Sustainability; and iii) Technical. Khoukhi *et al.* (2020) emphasised that retrofitting existing buildings is not only about saving energy but rather using an integrated approach in the design philosophy to generate a high-performance facility. In their study, Alfaiz *et al.* (2021) found five main CSF that influence GBR in Iraq, namely effective legislation, the competency of the project team, tax incentives, adequate experience and competency of the project manager.

Research done in China by Jin *et al.* (2014) demonstrated that GBR plays an important role in reducing energy consumption, however an integrated approach between stakeholders is required for successful implementation. The benefits of the industry chain were identified as environmental, economic, and social aspects. Eames *et al*.'s (2014) report found nine important success considerations that can be implemented to produce environmentally friendly future cities for the United Kingdom, namely i) an inclusive urban retrofit agenda; ii) compelling retrofit city visions; iii) improved modelling and decision support tools; iv) institutional capacity, planning and governance; v) access to 'green finance; vi) effective partnerships (bring the private sector in as partners in retrofitting projects, thus generating capital and risk sharing between the public and private sectors); vii) the public sector, through

policy changes, can encourage investment; viii) long-term sharing of risks and benefits and ix) a whole system perceptive. Interestingly, Jagarajan *et al.* (2017) emphasised the need to establish the main success factors to increase the prospect of successful implementation of GBR projects due to the absence of similar research.

Ma *et al.* (2021), cited by Geldenhuys (2017), identified human factors, retrofit technologies, policies and regulations, client resources and expectations and building-specific information and other uncertainty factors as six CSF influencing the success of a retrofitting project. The accompanying references are displayed in the table below.

Table 3: CSF of GBR

No.	CSF of GBR	References
1	Project management triangle	Bu *et al.*, 2015
2	Sustainability triangle	Bu *et al.*, 2015
3	Technical triangle	Bu *et al.*, 2015
4	Integrated approach	Khoukhi *et al.*, 2020; Jin *et al.*, 2014
5	Environmental benefits	Jin *et al.*, 2014
6	Economic benefits	Jin *et al.*, 2014
7	Social benefits	Jin *et al.*, 2014
8	An inclusive urban retrofit agenda	Eames *et al.*, 2014
9	Compelling retrofit city visions	Eames *et al.*, 2014
10	Improved modelling and decision support tools	Eames *et al.*, 2014
12	Access to ‘green finance’	Eames *et al.*, 2014
13	Effective partnerships	Eames *et al.*, 2014
14	Long-term sharing of risks and benefits	Eames *et al.*, 2014
15	A whole system of perceptive	Eames *et al.*, 2014

Source: Author’s own

From the literature review above, a lot more needs to be done in terms of raising awareness of retrofitting existing buildings to combat global warming amongst all stakeholders. This cannot be done at the project level - strategic planning at the government level is required to

incentivise the building owners to invest in retrofitting projects, as opposed to investing in the construction of new commercial buildings. The rate at which new buildings are constructed is not enough to reduce energy consumption in the short term, therefore, retrofitting the existing building stock is the solution. However, more research should be done to guide stakeholders.

2.4 SIGNIFICANCE OF LITERATURE REVIEW

The literature review provides the reader an outline of the extent or the knowledge, the challenges, benefits and CSF of existing office GBR. There is a need to address the steady increase in GHG in developing countries in general and SA specifically, together with the role the construction industry plays in this increase that has been witnessed over the years. The construction industry has been regarded as an industry with the ability to address the challenge of GHG based on the influence it wields over other sectors of the economy. Therefore, this study seeks to contribute to the knowledge of the challenges, benefits and CSF that drive the implementation of office GBR in CoJ. The next section will describe the theoretical framework for the study.

2.5 THEORETICAL FRAMEWORK

Wan *et al.* (2022) used the sustainability theoretical framework in their study of an existing office building in Beijing for EE retrofitting. This framework is based on economic, environmental, and social sustainability as the three main pillars, with the emphasis on three aspects, namely i) financial return; ii) energy consumption/environmental impact and iii) external benefits. The authors suggested the use of an integrated technological approach over and above the overall energy reduction and financial benefits. Figure 2 below illustrates the sustainability theoretical framework.

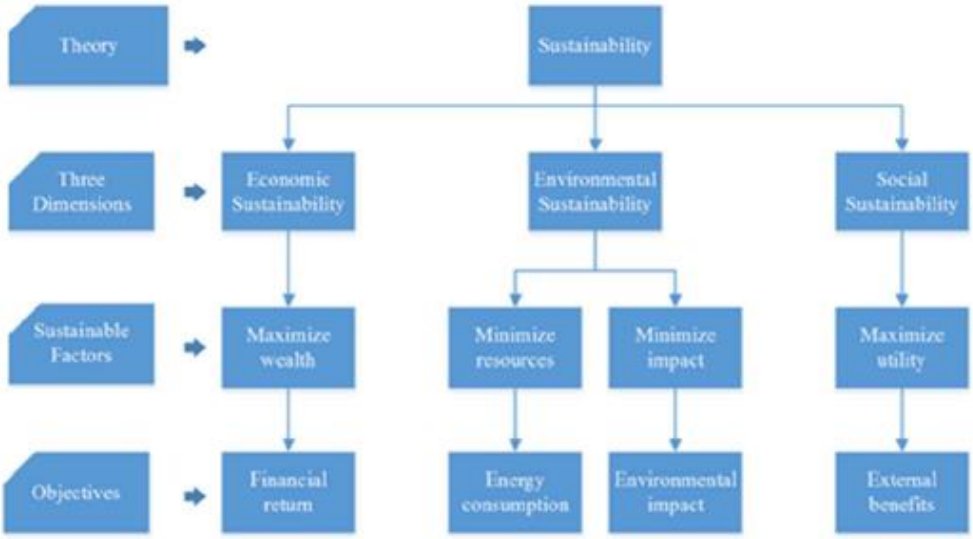


Figure 2: Framework of sustainable development of building retrofits adapted (Wan, Ding, Runeson & Liu, 2022)

Wan *et al.*'s (2022) framework is relevant to this study as the sustainability of existing building retrofits cannot be viewed from a single approach but rather from multiple approaches such as economic, environmental, and social. According to an article by Chang *et al.* (2017), the sustainability theory development relating to firms was conceived many years ago. This theory evolution is stated below and presented in Figure 3 thereafter.

i. Between 1953 – 1984: Corporate social responsibility (CSR) was characterised by the need of companies to use their position of power to improve the livelihood of the society they are operating in for potential future economic gains;
ii. Between 1984 – 1987: Stakeholder theory was characterised by the need for companies to consider the requirements of primary and secondary stakeholders in their strategy for effective management, strategy implementation and long-term survival;
iii. Between 1987 – 2005: Corporate sustainability (CS) was characterised by companies' need to consider the requirements of all stakeholders whilst upholding the balance between the 'economic, environmental and social' aspects; and
iv. Currently (from 2008): Green economics is characterised by the need of companies to consider preserving the environment for their future growth by investing in greener initiatives to improve their operation and by developing policies that encourage trading with other green conscience organisations.

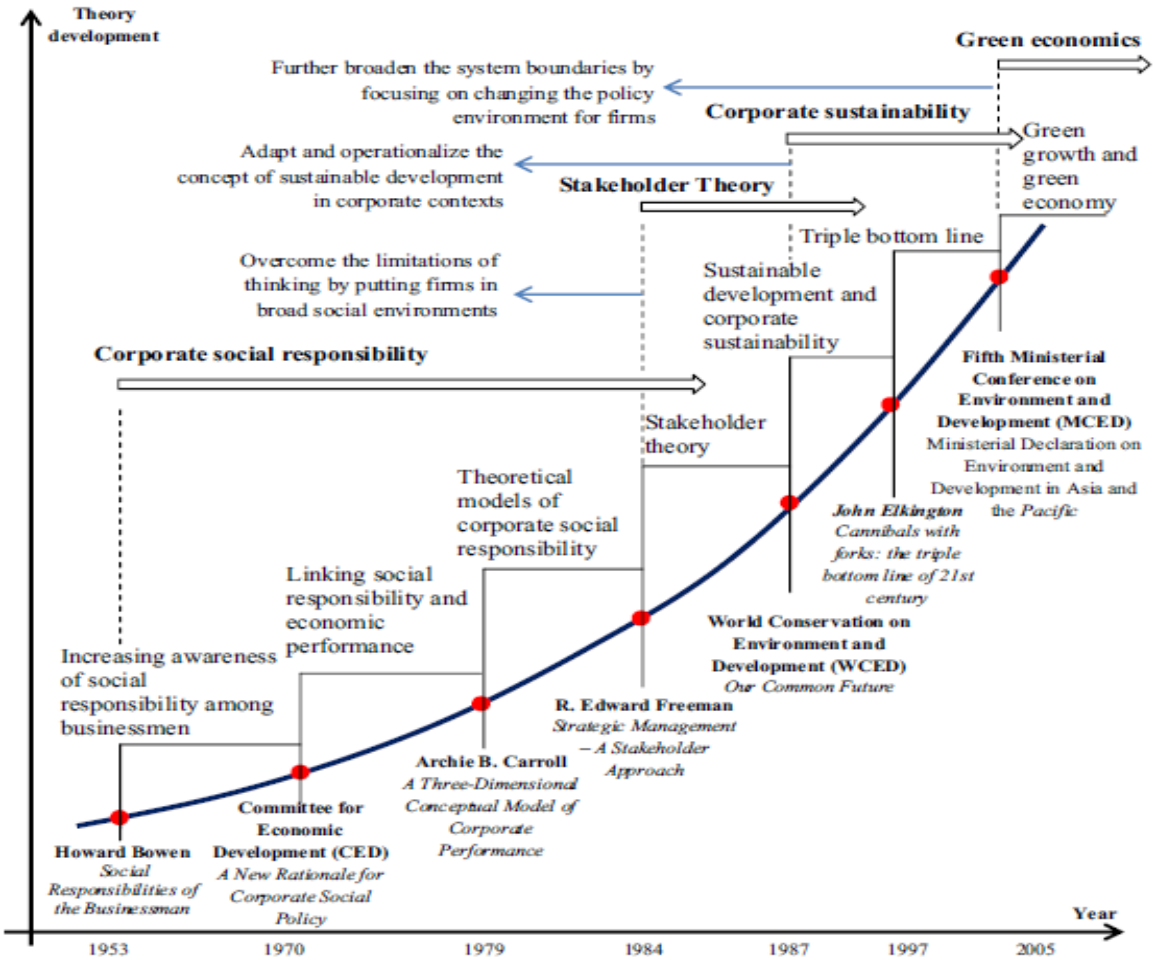


Figure 3: Evolution of related theories (Chang *et al.,* 2017)

The green economy includes overall aspects of sustainable development and is relevant in the SA context. Green economy goals include, among others, the reduction of GHG, economic growth and climate change resilience, which are all at the core of GBR as part of sustainable development (Nhamo, 2013). Kennet and Heinemann's (2006) study highlighted aspects of what the green economy is meant to address. These include ecological/economic resources; intellectual in terms of considering future generations in current strategies; political aspects in terms of crafting policies that support green initiatives; and moral in terms of poverty eradication and equality. For this study, the green economics framework will be adopted as it is relevant and incorporates all aspects of sustainability and long-term strategic views crucial to SA. The next section will present the green economics framework and how it is related to this study as a conceptual framework.

2.6 CONCEPTUAL FRAMEWORK

Mickaityte *et al.* (2008) adopted a conceptual model of six interrelated dimensions crucial in the process from the collection of data to the implementation of the building's refurbishment, these dimensions are technical, economic, architectural, social and ecological. This framework is relevant for this study as it incorporates six dimensions important to decision-making and results in the successful implementation of GBR. The six different dimensions (technical, economic, architectural, social, ecological and cultural) are part of the micro and macro levels application of the green economic theory. The micro dimension of the green economic theory as it relates to public building refurbishment includes information collection; decision modelling; solution selection and implementation. Figure 4 below provides a graphic representation of the conceptual framework.

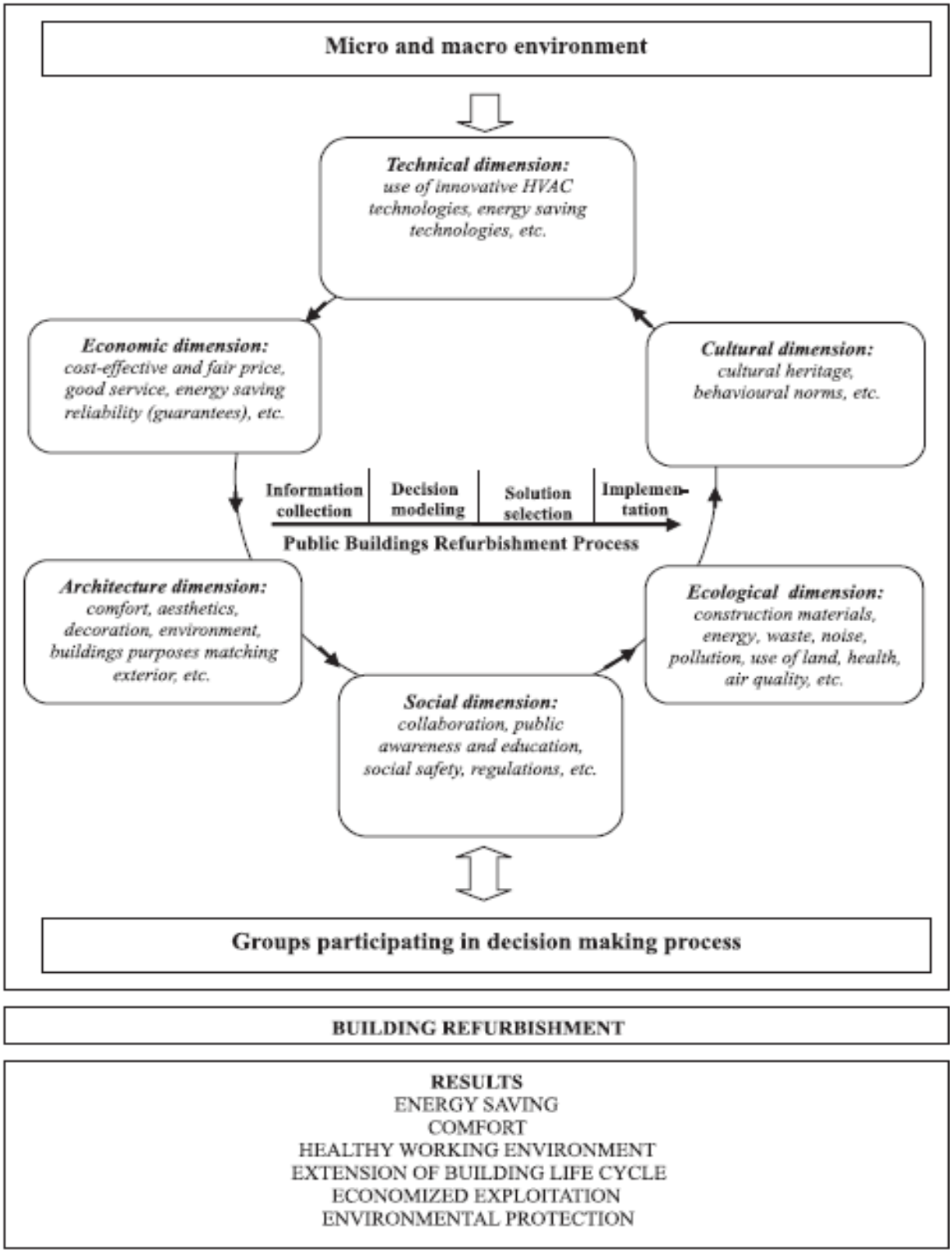


Figure 4: Conceptual model for sustainable building refurbishment (Adapted from Mickaityte *et al.*, 2008)

Beyond the micro dimension of the green economic theory used in framing this study, the macro level of the theory suggests the importance of group participation in the decision-making process for the ideal retrofitting requirements for any existing building. The group participants include every stakeholder in the required building (*Mickaityte et al*.,2008). The theory suggests that the ideal outcome of existing building refurbishment should include energy saving, comfort, a healthy working environment, extension of the building's life span, economised exploitation, and environmental protection (*Mickaityte et al*.,2008).

2.7 CHAPTER CONCLUSION

The impact of economic activities on the environment should be a source of concern to everyone. The construction sector has made attempts to introduce concepts aimed at mitigating the impact of the sector on the environment. These have led to the introduction of GBR. The more existing buildings are retrofitted, the more sustainable the construction sector would be.

CHAPTER THREE: RESEARCH METHODOLOGY AND DESIGN

3.1 INTRODUCTION

To examine the facts with objectivity and detachment, this study employs a quantitative technique to investigate the phenomenon of existing office building retrofitting in the CoJ. Primary data (online questionnaire survey) was used to assess the relationships between variables. The online questionnaires were divided into four sections, the first section covered the background information of respondents. The second, thirst and fourth sections included questions with measurement variables. A five-point Likert-type scale was used and respondents were asked to indicate how much they agreed or disagreed with each variable to assess the challenges, benefits and CSF for retrofitting existing office buildings in CoJ. The five-point Likert-type scale used was described as follows: 1 – Strongly disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; and 5 – Strongly agree. Built environment professionals were requested to participate in the online questionnaire survey. The next section will present the research approach and design as applied in the study.

3.2 RESEARCH APPROACH AND DESIGN

Three alternative research designs can be used namely, quantitative, qualitative, and mixed methods. According to Creswell (2014), the quantitative method includes experiments design and no experiments design, such as surveys. This design developed over time and was based on the postpositivist worldview attributed primarily to psychology. It includes "testing objective theories also known as hypotheses by examining the relationship among variables. These variables can be measured, typically on instruments, so that numbered data can be analysed using statistical procedures" (Creswell, 2014, p.292).

The qualitative method includes grounded theory, narrative research, and case study. According to Creswell (2014, p.292), this method originated from social science and anthropology and includes:

> *Exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures; collecting data in the participants' setting; analysing the data inductively, building from particulars to general themes; and making interpretations of the meaning of the data.*

The mixed method incorporates the use of quantitative and qualitative research. This method was developed to eliminate the disadvantages between both quantitative and qualitative data and includes convergent, explanatory and exploratory sequential and transformative approaches, predetermined and evolving methods; as well as open-and closed-ended questions. It involves “philosophical assumptions, the use of qualitative and quantitative approaches and the mixing or integrating of both approaches in a study” (Creswell, 2014, p.292). A quantitative method is employed for this study. The next section will describe the source of the data for the study.

3.3 DATA AND DATA SOURCES

The study was conducted in the CoJ and the target respondents were the built environment professionals within the city. These respondents were required to have experience in retrofitting projects. The next section describes the nature of the research instrument.

3.4 DATA COLLECTION INSTRUMENTS

A questionnaire survey was used as a data collection instrument in this study. Data were collected with the guide of the questionnaire as a means of assessing the factors influencing GBR in the CoJ, as well as the challenges, benefits and CSF of GBR.

The questionnaire was structured in a commonly understood language (English), for ease of reference and comprehension. The questionnaire had four sections, these are *Section A – Background Information, Section B – Challenges of retrofitting existing office buildings, Section C – Benefits of retrofitting* and *Section D – CSF of retrofitting*. The research instruction was administered to get the respondents to answer the survey questions appropriately. Section 3.5 below presents the data collection period.

3.5 DATA COLLECTION PERIOD

The online questionnaire was distributed electronically. The results were collected throughout November 2022.

3.6 DATA ANALYSIS

This study seeks to evaluate aspects influencing the retrofitting of existing office buildings in the CoJ, including the difficulties and advantages of doing so as well as CSF for retrofitting existing office buildings to mitigate energy consumption in the CoJ. The online survey classified the challenges, benefits and CSF in line with the green economic theoretical paradigm. The data from the survey were analysed using descriptive and inferential statistics. Descriptive statistics show the properties or characteristics of the study sample while inferential statistics make predictions about what would be found in the population based on what is found in the sample. Inferential statistics are used to draw an inference or make meaning of the study population via hypotheses testing (Creswell, 2014). Descriptive statistics made use of charts, including bar charts and pie charts to describe the categorical variables from the respondents. The categorical variables include gender, educational qualification, the operational level at the different organisations, as well as professional experience and work experience in office building retrofitting. The inferential statistics used a T-test to measure the statistical attributes of the variables concerning the ROs and hence test the hypotheses using p-values. A confidence level of 95% was used to test the research hypotheses. The statistics measuring central tendency and level of dispersion were also explored by ranking the different variables in order of importance. The interval scale of the five-point Likert-type scale was used to assess the different levels of agreement or disagreement of the respondents to the different survey questions. The mean responses were very significant, and variables were ranked using the mean score ranking technique to determine the significance of every variable in descending order. Microsoft Excel was used to clean up, arrange and code the data while the Statistical Package for Social Science (SPSS) was used to analyse the data, using the following scale:

- 1 -1.8 = Strongly disagree (SDi)
- 1.81 – 2.60 = Disagree (D)
- 2.61 – 3.40 = Neutral (N)
- 3.41 – 4.20 = Agree (A)
- 4.21 – 5 = Strongly agree (SAg)

3.7 POPULATION AND SAMPLING

The population for this study comprised professionals in the built environment including facilities managers, architects, electrical and mechanical engineers, quantity surveyors and real estate developers who are knowledgeable in office building retrofitting. This study adopted a purposive sampling technique, also known as the targeted sampling technique. The sample size was drawn from the built environment professionals. A total of 100 professionals from the built environment were targeted as the study sample and 71 out of the 100 respondents participated in the survey, 71% of the sample size. Furthermore, the instrument for data collection from respondents was an online structured questionnaire.

3.8 LIMITATIONS

This study was carried out in the CoJ and the respondents were limited to built environment professionals. The study only evaluates retrofitting of office buildings, including the challenges, benefits, and CSF of retrofitting existing office buildings.

3.9 RELIABILITY AND VALIDITY

Reliability and validity were addressed in the data collected for this study. Reliability is the degree to which the data gathering, and analytical methods would produce similar results whenever repeated by different researchers and free from biases and errors. Validity is the degree to which data gathered measures what it intends to (Cohen, Manion & Morrison, 2018). Four types of validity in quantitative research were discovered by Shadushu *et al.* (2002), namely construct, statistical conclusion, internal and external.

3.10 ETHICAL CONSIDERATION

Firstly, this study considered other researchers within the built environment who have and will still contribute to the literature of this study by ensuring their work receives the necessary recognition. Secondly, this study protected the respondents' interest by keeping them well-informed on the purpose of the study and on what basis they were selected. In addition, respondents have assured protection through anonymity and were not coaxed into participating in the survey.

3.11 CHAPTER SUMMARY

This chapter described the rationale of the study, the methods adopted to determine respondents and the method of data collection. It described the data sample, data source and data collection instruments. It also conveyed the method of data analysis intending to achieve the study ROs. In addition, this chapter identified the limitations and discussed the reliability and validity of the data and ethical considerations employed for this study. The next chapter will present the analysis of the data.

CHAPTER FOUR: DATA ANALYSIS

4.1 INTRODUCTION

This chapter outlines the results from the online questionnaire issued to the built environment professionals in the CoJ. The sample of this study was 100 respondents; however, responses from 71 respondents were received and formed the basis of this analysis (a 71% response rate). Tables and charts were used to construe the data.

The questionnaire survey included four sections; the first section explored the background information of the participants. The second section of the questionnaire included established factors affecting the challenges of retrofitting existing office buildings, the third section included established factors depicting the benefits of retrofitting existing office buildings and lastly, the fourth section included established CSF influencing retrofitting of existing office buildings. This analysis is limited to existing office buildings in the CoJ.

4.2 DATA ANALYSIS

This section describes the analysed and includes four sub-sections incorporating demographic information, challenges, benefits, and CSF of retrofitting office buildings.

Cronbach's alpha was used to measure the internal consistency of the variables. The alpha values for the respective ROs were as follows: RO1 – Examining the challenges of retrofitting office buildings had an internal consistency of ($\propto$=0.816). RO2 – Evaluating the benefits of retrofitting office buildings had an internal consistency of ($\propto$=0.911). RO3 – Assessing the CSF for retrofitting office buildings had an internal consistency of ($\propto$=0.954). These results, therefore, confirmed the reliability of the variables considered in the survey data.

4.2.1 Section A: Background information

The first part of the descriptive statistical analysis was an assessment of the categorical variable, *Gender*. The survey sought to classify the respondents into female, male and others, in a bid to understand their gender orientation.

The total sample of built environment professionals in the CoJ consisted of 25 (35.2%) females and 46 (64.8%) males (respondents – *n*=71). Table 4 below shows the frequency distribution for gender and Figure 5 thereafter is a descriptive presentation of the respondents' gender on a bar chart.

Table 4: Frequency distribution for gender

	Frequency	%
Male	46	64.8
Female	25	35.2
Others	0	0.0
Total	**71**	**100.0**

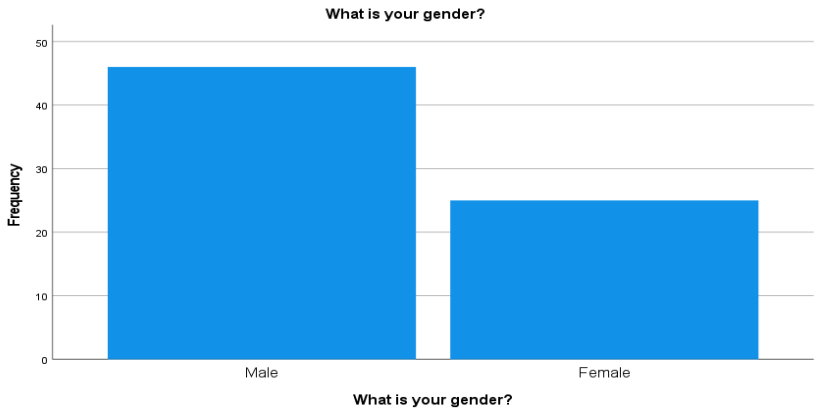


Figure 5: Frequency distribution of gender

The next part of the descriptive statistics sought to assess the respondents' *Level of education/qualification*. This provided a level of credibility to the study. Respondents' educational qualifications ranged from Bachelor's (BA), Honours (Hons) and Master's (M) degrees, to a Master of Business Administration (MBA) and Doctor of Philosophy (PhD).

The total sample of built environment professionals in the CoJ consisted of 18 (25.4%) BAs, 20 (28.2%) Hons, 32 (45.1%) Ms and one (1.4%) MBA (*n*=71). Table 5 below shows the frequency distribution for level of education. Figure 6 thereafter is a descriptive presentation of the respondents' highest level of education.

Table 5: Frequency distribution for highest level of education

	Frequency	%
BA	18	25.4
Hons	20	28.2
M	32	45.1
MBA	1	1.4
PhD	0	0.0
Total	**71**	**100.0**

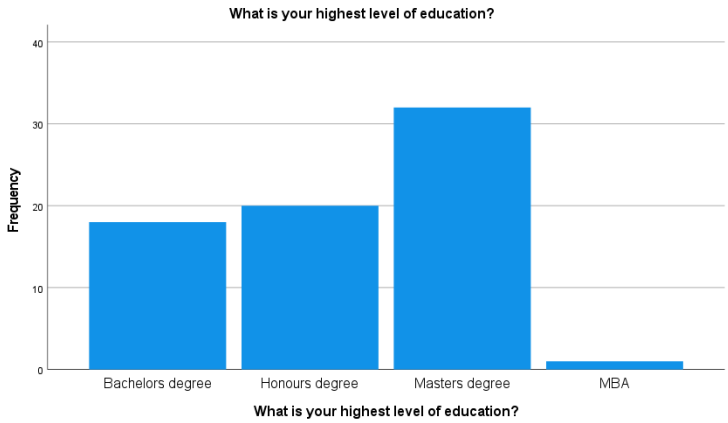


Figure 6: Frequency distribution for highest level of education

The next part of the descriptive statistical analysis was an assessment of the categorical variable, *Level of the respondents in the organisation*. The survey sought to classify the respondents in terms of junior management, senior management, professional staff, manager middle manager and director executive manager, in a bid to understand the position of the respondents in the different organisations.

The total sample of built environment professionals in the CoJ consisted of 12 (16.9%) junior management, 25 (35.2%) senior management, nine (12.7%) professional staff, 11 (15.5%) manager middle management and 14 (19.7%) director executive manager (*n*=71). Table 6 below shows the frequency distribution for respondents' levels in the organisation. Figure 7 thereafter is a descriptive presentation of the respondents' level in the organisation on a pie chart.

Table 6: Frequency distribution for level in organisation

	Frequency	%
Junior management	12	16.9
Senior management	25	35.2
Professional staff	9	12.7
Manager middle management	11	15.5
Director executive manager	14	19.7
Total	**71**	**100.0**

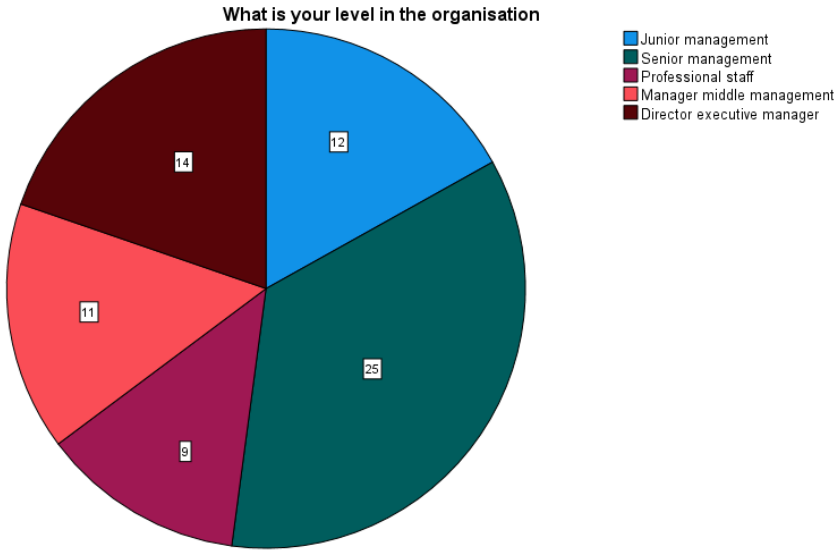


Figure 7: Frequency distribution for level in the organisation

The next part of the descriptive statistical analysis was an assessment of the categorical variable, *Professional experience of the respondents in the organisation*. The survey sought to classify the respondents in terms of how many years of experience the respondents had acquired in the organisation.

The total sample of built environment professionals in the CoJ consisted of a range of experience; 14 (19.7%) had 1-5 years, 18 (25.4%) had 6-10 years, 16 (22.5%) had 11-15 years, nine (12.7%) had 16-20 years and 14 (19.7%) had more than 20 years (*n*=71). Table 7 below shows the frequency distribution for respondents' years of experience. Figure 8 thereafter is a descriptive presentation of the respondents' years of professional experience on a bar chart.

Table 7: Frequency distribution for years of experience

	Frequency	%
1-5 years	14	19.7
6-10 years	18	25.4
11-15 years	16	22.5
16-20 years	9	12.7
Above 20 years	14	19.7
Total	**71**	**100.0**

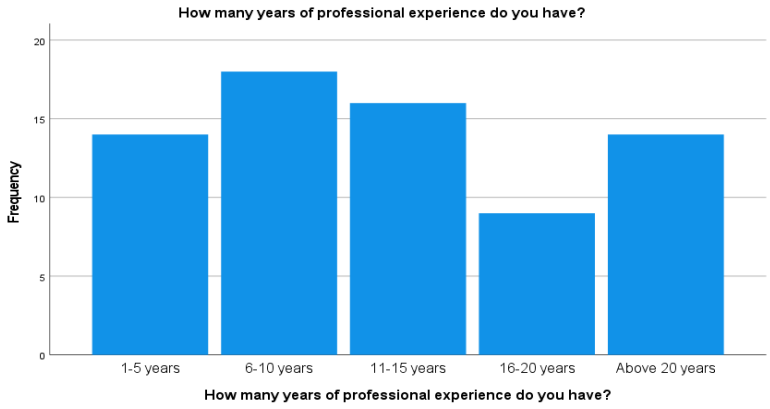


Figure 8: Frequency distribution for professional experience

This part of the descriptive statistics sought to assess the years of experience of the different respondents in managing office building projects (*Work experience*). This provided a level of credibility to the study. Respondents' years of experience in managing office building projects are grouped into less than 12 months, 1-5 years, 6-10 years, 11-15 years, 16-20 years and more than 20 years.

The total sample of built environment professionals in the CoJ consisted of six (8.5%) with less than 12 months of work experience with managing office building projects, 28 (39.4%) with 1-5 years, 19 (26.8%) with 6-10 years, seven (9.9%) with 11-15 years, eight (11.3%) with 16-20 years and three (4.2%) with more than 20 years of experience (*n*=71).

Table 8 below shows the frequency distribution for work experience in managing office building projects. Figure 9 thereafter is a descriptive presentation of the respondents' years of experience in managing office-building projects.

Table 8: Frequency distribution for years of experience in managing office building projects

	Frequency	%
Less than 12 months	6	8.5
1-5 years	28	39.4
6-10 years	19	26.8
11-15 years	7	9.9
16-20 years	8	11.3
20 years and above	3	4.2
Total	**71**	**100.0**

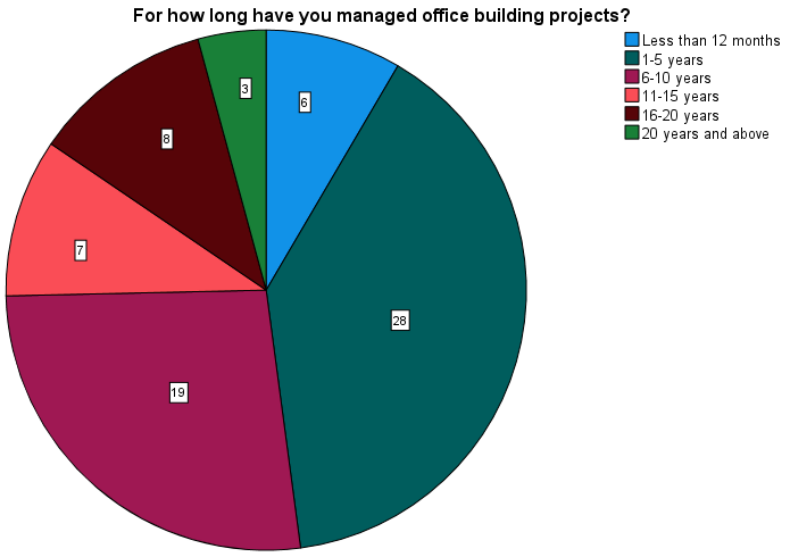


Figure 9: Frequency distribution for experience in managing office building projects

The next section presents the analyses of inferential statistics to test the hypotheses. The interval scale of the five-point Likert scale was used to assess the different levels of agreement or disagreement of the respondents to the different survey questions. The mean responses were particularly important in determining the level of agreement or disagreement with the responses, varying from 1-5 (see Section 3.6). T-test was used to test the hypotheses. Where the p-value was less than or equal to 0.05, the null hypothesis was rejected, and the alternate hypothesis was accepted. The variables for RO3 were thereafter ranked for RII using the mean score ranking technique to determine the weighting of each variable in ascending order. The analyses for inferential data are presented on objective-by-objective cases.

4.2.2 Section B: Challenges of retrofitting office buildings

The mean of the interval scale of the five-point Likert-type scale is important for the explanation of the outcome of the sample statistics within this section. As a short reminder (see Section 3.6): 1 -1.8 = SDi; 1.81 – 2.60 = D; 2.61 – 3.40 = N; 3.41 – 4.20 = A and 4.21 – 5 = SAg.

From the analysis output from SPSS, the details include the variables, number of respondents (*n*), variable mean, standard deviation (SD) and standard error mean. From the output, 71 respondents returned the survey. The mean for the different variables, the SD and the standard error of the mean are presented in the tables and sub-sections below.

RO1 sought to examine the challenges of retrofitting office buildings in the CoJ by asking *To what extent do you agree or disagree that the following variables are the challenges of retrofitting office buildings in the CoJ?*

H_{01}: There are no challenges with retrofitting existing office buildings in the CoJ.

H_{A1}: There are challenges with retrofitting existing office buildings in the CoJ.

Using SPSS, an individual sample T-Test analysed the population mean for variables regarding *challenges with retrofitting existing office buildings* in the CoJ (Tables 9 and 10). Table 10 hereafter is the sample test for the hypothesis.

Table 9: Sample statistics showing the challenges of retrofitting existing office buildings in the CoJ

Sample Statistics: To what extent do you agree or disagree that the following are the challenges of retrofitting office buildings in the CoJ?

Variables	N	Mean	Std. Deviation	Std. Error Mean
Lack of government incentives	71	3.86	1.162	.138
Budget constraints	71	3.83	1.276	.151
Longer payback period	71	3.59	.979	.116
Technical challenges	71	3.38	1.223	.145
Disruption of and inconvenience to the tenant during retrofitting	71	3.38	1.269	.151
Uncertainty on ROI	71	3.38	1.163	.138
Lack of database for retrofitting information	71	3.37	1.210	.144
Government regulations	71	3.34	1.195	.142
The building space is too small and tenants would rather relocate	71	3.25	1.143	.136
Lack of benchmarking for office retrofitting	71	3.15	1.191	.141
Lack of demand for sustainable office buildings	71	3.08	1.452	.172
Lack of professional team expertise	71	2.58	1.306	.155

Colour code: Blue (agree), Green (neutral), Yellow (disagree)

Table 10: Sample test showing the challenges of retrofitting existing office buildings in the CoJ

Sample Test: To what extent do you agree or disagree that the following are the challenges of retrofitting office buildings in the CoJ?

	Test Value = 0						
			Significance			95% Confidence Interval of the Difference	
Variables	t	df	One-Sided p-value	Two-Sided p	Mean Difference	Lower	Upper
Lack of government incentives	27.973	70	<.001	<.001	3.859	3.58	4.13
Budget constraints	25.298	70	<.001	<.001	3.831	3.53	4.13
Longer payback period	30.897	70	<.001	<.001	3.592	3.36	3.82
Technical challenges	23.286	70	<.001	<.001	3.380	3.09	3.67
Disruption of and inconvenience to the tenant during retrofitting	22.444	70	<.001	<.001	3.380	3.08	3.68
Uncertainty on ROI	24.484	70	<.001	<.001	3.380	3.10	3.66
Lack of database for retrofitting information	23.442	70	<.001	<.001	3.366	3.08	3.65
Government regulations	23.546	70	<.001	<.001	3.338	3.06	3.62
The building space is too small and tenants would rather relocate	23.987	70	<.001	<.001	3.254	2.98	3.52
Lack of benchmarking for office retrofitting	22.320	70	<.001	<.001	3.155	2.87	3.44
Lack of demand for sustainable office buildings	17.905	70	<.001	<.001	3.085	2.74	3.43
Lack of professional team expertise	16.634	70	<.001	<.001	2.577	2.27	2.89

Classification - Public

As the study made use of confidence levels in the tests, the test value was equal to 0. The mean difference was similar to the mean in the sample statistics in Table 9. The difference was simply a subtraction of the margin of error as conducted by SPSS, which eventually generated the lower and upper boundaries of the confidence intervals for a 95% confidence level for the population mean. The p-values were used to assess which variables contributed to accepting or rejecting the research hypothesis. For RO1, the null hypothesis was rejected, and the alternative hypothesis was accepted.

The factors that contributed to the challenges of retrofitting office buildings in the CoJ were: lack of government incentives (mean = 3.86, SD = 1.162); budget constraints (mean = 3.83, SD = 1.237); longer payback period (mean = 3.59, SD = 0.979). The respondents were neutral on variables such as technical challenges (mean = 3.38, SD = 1.223); disruption of and inconvenience to the tenant during retrofitting (mean = 3.38, SD = 1.269); uncertainty on ROI (mean = 3.38, SD = 1.163); lack of a database for retrofitting information (mean = 3.37, SD = 1.210); government regulations (mean = 3.34, SD = 1.195); building space too small and tenants would rather relocate (mean = 3.25, SD = 1.143); lack of benchmarking for office retrofitting (mean = 3.15, SD = 1.191); and lack of demand for sustainable office buildings (mean = 3.08, SD = 1.452). Respondents disagreed that the lack of professional team expertise (mean = 2.58, SD = 1.306) is a challenge to retrofitting existing office buildings in the CoJ.

Due to the large SDs of the variables, which suggest that there is not a significant statistical difference between the interacting variables, the T-test was conducted on the same variables to determine the p-values which provided a better suggestion to either accept or reject the research hypothesis. The T-test was performed over a 95% confidence level. Hence, a p-value less than 0.05 suggested that the null hypothesis is not true. This invariably validated the alternate hypothesis. Tables 9 and 10 presented the output of the T-test for evaluating the hypothesis. The finding indicates that all the variables presented a p-value of less than 0.001 (which is less than 0.05). This is suggestive that, although the respondents differ in their levels of agreement as seen with the mean values of the sample statistics (Table 9), all the tested variables are statistically suggestive (Table 10, p-values) that there are challenges with retrofitting existing office buildings in the CoJ.

Classification - Public

4.2.3 Section C: Benefits of retrofitting office buildings

RO2 sought to evaluate the benefits of retrofitting existing office buildings in the CoJ by asking *To what extent do you agree or disagree that the following variables are the benefits of retrofitting existing office buildings in the CoJ?*

H_{02}: There are no benefits to retrofitting existing office buildings in the CoJ.

H_{A2}: There are benefits to retrofitting existing office buildings in the CoJ.

Using SPSS, an individual sample T-Test analysed the population mean for variables of the *benefits of retrofitting existing office buildings* in the CoJ using the SPSS (Tables 11 and 12). Table 12 hereafter is the sample test for the hypothesis.

Table 11: Sample statistics showing the benefits of retrofitting existing office buildings in the CoJ.

Sample statistics: To what extent do you agree or disagree that the following are the benefits of retrofitting office buildings in the CoJ?

Variables	N	Mean	Std. Deviation	Std. Error Mean
Improved EE	71	4.13	1.055	.125
Enhanced marketability of the buildings	71	3.94	1.107	.131
Improved building climate control	71	3.89	1.049	.125
Reduced energy consumption	71	3.85	1.179	.140
The reduced operational cost of building	71	3.79	1.094	.130
Improved level of satisfaction of occupants	71	3.79	1.013	.120
Increased productivity of workers	71	3.66	1.055	.125
Improved corporate community responsibility	71	3.55	1.106	.131
Decreased GHG	71	3.55	1.106	.131
Protects the ecosystem and biodiversity	71	3.51	.984	.117

Colour code: Blue (agree)

Table 12: Sample test showing the benefits of retrofitting existing office buildings in the CoJ

Sample Test: To what extent do you agree or disagree that the following are the benefits of retrofitting existing office buildings in the CoJ?

	Test Value = 0						
			Significance			95% Confidence Interval of the Difference	
Variables	t	df	One-Sided p-value	Two-Sided p	Mean Difference	Lower	Upper
Improved EE	32.971	70	<.001	<.001	4.127	3.88	4.38
Enhanced marketability of the buildings	30.019	70	<.001	<.001	3.944	3.68	4.21
Improved building climate control	31.211	70	<.001	<.001	3.887	3.64	4.14
Reduced energy consumption	27.481	70	<.001	<.001	3.845	3.57	4.12
The reduced operational cost of building	29.172	70	<.001	<.001	3.789	3.53	4.05
Improved level of satisfaction of occupants	31.515	70	<.001	<.001	3.789	3.55	4.03
Increased productivity of workers	29.252	70	<.001	<.001	3.662	3.41	3.91
Improved corporate community responsibility	27.048	70	<.001	<.001	3.549	3.29	3.81
Decreased GHG	27.048	70	<.001	<.001	3.549	3.29	3.81
Protects the ecosystem and biodiversity	30.038	70	<.001	<.001	3.507	3.27	3.74

Classification - Public

After the confidence level (95%) was applied, the test value was equal to 0. The mean difference was similar to the mean in the sample statistics in Table 11 above. The difference was a subtraction of the margin of error as conducted by SPSS. The margin of error eventually generated the lower and upper boundaries of the confidence intervals for a 95% confidence level for the population mean. The p-values are used to assess which variables contributed to accepting or rejecting the second research hypothesis. For RO2, the null hypothesis was rejected, and the alternative hypothesis was accepted.

The variables were ranked in descending order of the mean. The factors that contributed to the benefits of retrofitting existing office buildings in the CoJ were: improved EE (mean = 4.13; SD = 1.055); enhanced marketability of the buildings (mean = 3.94; SD = 1.107); improved building climate control (mean = 3.89; SD = 1.049); reduced energy consumption (mean = 3.85; SD = 1.179); reduced operational cost of building (mean = 3.79; SD = 1.094); improved level of satisfaction of occupants (mean = 3.79; SD = 1.013); increased productivity of workers (mean = 3.66; SD = 1.055); improved corporate community responsibility (mean = 3.55; SD = 1.106); decreased GHG (mean = 3.55; SD = 1.106); and protects the ecosystem and biodiversity (mean = 3.51; SD = 0.984). All the respondents agreed that these variables are part of the benefits of retrofitting an existing office building.

However, due to the large SDs of the variables which suggest that there was not a significant statistical difference between the interacting variables, a T-test was conducted on the same variables to determine the p-values which gives a better suggestion to either accept or reject the research hypothesis. The T-test was performed over a 95% confidence level. Hence, a p-value less than 0.05 suggested that the null hypothesis is not true. This invariably validated the alternate hypothesis. Tables 11 and 12 presented the output of the T-test for evaluating the hypothesis. The finding indicates that all the variables presented a p-value of less than 0.001 which is less than 0.05. This is suggestive that in addition to the respondents agreeing that the tested variables are benefits of retrofitting existing office buildings as seen with the mean values of the sample statistics (Table 11), all the tested variables were statistically significant (Table 12, p-values) that there are benefits with retrofitting existing office buildings in the CoJ.

Classification - Public

4.2.4 Section D: CSF for retrofitting existing office buildings

RO3 sought to assess the CSF for retrofitting existing office buildings in the CoJ by asking *What are the CSF for retrofitting existing office buildings in the CoJ?* This answer was achieved via hypothesis testing. Thereafter, relative importance indices of the CSF were performed to assess the CSF for retrofitting existing office buildings in the CoJ.

H_{03}: There are no CSF for retrofitting existing office buildings in the CoJ.

H_{A3}: There are CSF for retrofitting existing office buildings in the CoJ.

Using SPSS, an individual sample T-Test was used to analyse the population mean for variables about the *CSF for retrofitting existing office buildings* in the CoJ (Tables 13 and 14). Table 14 below is the sample test for the hypothesis.

Table 13: Sample statistics showing the CSF for retrofitting existing office buildings in the CoJ.

Sample statistics: What are the CSF for retrofitting existing office buildings in the CoJ?

Variables	N	Mean	Std. Deviation	Std. Error Mean
Project cost control	71	4.24	1.165	.138
Communication	71	4.18	1.099	.130
Efficient planning and regulatory approvals between the municipality and project manager	71	4.03	1.230	.146
Project schedule management	71	4.00	1.134	.135
Competency of the project manager	71	4.00	1.219	.145
Teamwork among the project members	71	3.94	1.145	.136
Internal leadership	71	3.93	1.199	.142
Integrated stakeholder approach	71	3.90	1.097	.130
Project information management	71	3.87	1.055	.125
Effective partnerships between private and public sectors	71	3.61	1.213	.144
An inclusive urban retrofit agenda	71	3.61	1.201	.143

Colour code: Red (SAg), Blue (A)

Table 14: Sample test showing the CSF for retrofitting existing office building in the CoJ

Sample Test: What are the CSF for retrofitting existing office buildings in the CoJ?

	Test Value = 0						
			Significance			95% Confidence Interval of the Difference	
Variables	t	df	One-Sided p-value	Two-Sided p	Mean Difference	Lower	Upper
Project cost control	30.675	70	<.001	<.001	4.239	3.96	4.52
Communication	32.058	70	<.001	<.001	4.183	3.92	4.44
Efficient planning and regulatory approvals between the municipality and project manager	27.590	70	<.001	<.001	4.028	3.74	4.32
Project schedule management	29.725	70	<.001	<.001	4.000	3.73	4.27
Competency of the project manager	27.652	70	<.001	<.001	4.000	3.71	4.29
Teamwork among the project members	29.021	70	<.001	<.001	3.944	3.67	4.21
Internal leadership	27.614	70	<.001	<.001	3.930	3.65	4.21
Integrated stakeholder approach	29.954	70	<.001	<.001	3.901	3.64	4.16
Project information management	30.946	70	<.001	<.001	3.873	3.62	4.12
Effective partnerships between private and public sectors	25.051	70	<.001	<.001	3.606	3.32	3.89
An inclusive urban retrofit agenda	25.298	70	<.001	<.001	3.606	3.32	3.89

Classification - Public

The confidence level was also applied in the tests for the third hypothesis; hence the test value was equal to 0 and the confidence level adopted was 95%. The mean difference was almost the same as the mean in the sample statistics in Table 13 above. The difference was equally a subtraction of the margin of error as conducted by SPSS. The margin of error eventually generated the lower and upper boundaries of the confidence intervals for a 95% confidence level for the population mean.

To assess which factor was most critical for retrofitting existing office buildings in the CoJ, the third RO was subject to the RII test and the output was ranked in ascending order of the population mean. Table 15 below presents the RII ranking of the population mean for the CSF for *retrofitting existing office buildings* in the CoJ.

Table 15: RII for CSF for retrofitting office buildings in the CoJ

Descriptive statistics: RII for CSF for retrofitting office buildings in the CoJ

Variables	N	Mean	Std. Deviation
An inclusive urban retrofit agenda	71	3.61	1.201
Effective partnerships between private and public sectors	71	3.61	1.213
Project information management	71	3.87	1.055
Integrated stakeholder approach	71	3.90	1.097
Internal leadership	71	3.93	1.199
Teamwork among the project members	71	3.94	1.145
Project schedule management	71	4.00	1.134
Competency of the project manager	71	4.00	1.219
Efficient planning and regulatory approvals between the municipality and project manager	71	4.03	1.230
Communication	71	4.18	1.099
Project cost control	71	4.24	1.165
Valid N (listwise)	71		

The RII was ranked in ascending order of the population mean. Further explanation of the statistical analysis and the implications of the different values and findings is presented in the discussion and interpretation section of the next chapter of the study.

The mean scores presented a determination that the CSF of retrofitting office buildings in the CoJ was project cost control (mean = 4.24; SD = 1.165), which was strongly accepted. Respondents also agreed with communication (mean = 4.18; SD = 1.099); efficient planning and regulatory approvals between the municipality and project manager (mean = 4.03; SD = 1.230); project schedule management (mean = 4.00; SD = 1.134); competency of the project manager (mean = 4.00; SD = 1.219); teamwork among the project members (mean = 3.94; SD = 1.145); internal leadership (mean = 3.93; SD = 1.199); integrated stakeholder approach (mean = 3.90; SD = 1.097); project information management (mean = 3.87; SD = 1.055); effective partnerships between private and public sectors (mean = 3.61; SD = 1.213) and an inclusive urban retrofit agenda (mean = 3.61; SD = 1.201). Some of the respondents strongly agreed while others agreed that these variables are part of the CSF of retrofitting an existing office building.

In a similar pattern, due to the large SDs of the variables which suggested that there was not a significant statistical difference between the interacting variables, a T-test was similarly conducted on the same variables to determine the p-values which give a better suggestion to either accept or reject the research hypothesis. The T-test was performed over a 95% confidence level. Hence, a p-value less than 0.05 suggested that the null hypothesis is not true. This invariably validated the alternate hypothesis. Table 14 presented the output of the T-test for evaluating the hypothesis. The finding indicates that all the variables presented a p-value of less than 0.001, which is less than 0.05. This is suggestive that in addition to the respondents agreeing that the tested variables are CSF in retrofitting existing office buildings as seen with the mean values of the sample statistics (Table 13), all the tested variables were statistically significant (Table 14, p-values) that the tested variables form a CSF of retrofitting existing office buildings in the CoJ.

4.3 CHAPTER SUMMARY

This chapter of the research captured the results from the questionnaires received from the participants and the analysis thereof. The information received was analysed and represented using tables and charts. Applications such as Excel and the SPSS were used for the analyses. The analyses included descriptive and inferential statistical analysis. The descriptive statistics analysed the data of the participant’s gender, highest

educational qualification, level in the organisation, number of years of professional experience and number of years of managing office building projects. The outcomes were displayed on charts, including bar charts and pie charts. The inferential statistics included T-test and RII. T-test was used to test the hypotheses for purposes of accepting or rejecting the null hypotheses. RII was used to rank the CSF to present the CSF prompting the retrofitting of existing office buildings in the CoJ. The study sought to evaluate aspects influencing the retrofitting of existing office buildings in the CoJ, including the difficulties, advantages and CSF.

The next chapter will provide a discussion of the findings from the study. This will enable an empirical and inferential conclusion of the study in line with the green economic theory, which provided a theoretical underpinning for the study.

CHAPTER FIVE: DISCUSSION AND FINDINGS

5.1 INTRODUCTION

This chapter elaborated on the results received and analysed in the preceding chapter. These results are discussed in line with the literature review in Chapter Two, as well as the theoretical underpinning to establish whether the ROs have been accomplished by the literature review and results from the preceding chapter.

5.2 BACKGROUND INFORMATION

This section provided background information. Although the researcher was aware of the sensitivity of the questions in this section, the information allowed the comparison of participant groups. The information detailed the respondent's gender, highest educational qualification, level in the organisation, number of years of professional experience and number of years managing office building projects.

5.3 RESEARCH OBJECTIVE ONE

RO1 sought to examine the challenges of retrofitting existing office buildings in the CoJ. To achieve this RO, the question *Are there challenges of retrofitting existing office buildings in CoJ?* was asked.

Since the research adopted a deductive theoretical approach, the research question was converted into a hypothesis to enable its testing against the established green economic theory using the survey data. The survey data were obtained through a five-point Likert-type scale to elicit the extent to which the respondents agreed or disagreed with the variables investigating the challenges of retrofitting existing office buildings in the CoJ.

H_{01}: There are no challenges with retrofitting existing office buildings in the CoJ.

5.3.1 Findings

The data received from the online questionnaire survey were analysed using sample statistical analysis from SPSS to obtain the mean population score, SD and standard error mean. Results were presented in Tables 9 and 10 in the previous chapter. The variables were ranked in descending order of the mean.

The results of factors contributing to challenges of retrofitting office buildings in the CoJ are supported by Jagarajan *et al.* (2016), who identified challenges in GBR in their study (unpredictability and hurdles in terms of government regulations, global warming, budget constraints, longer payback period, operations disruptions and constraints, lack of government incentives to support owners). The lack of government incentives ranked highly in this study; this is supported by research by Miller and Byes (2008) where the disposition of government was identified as the biggest challenge to sustainability. These results are supported by a survey conducted by Marquez *et al.* (2012) that highlighted expensive choices, lack of database and inability to trust available information as challenges to adopting EE measures for existing buildings. In addition, the authors identified other challenges such as capital limitations including longer payback periods, extreme execution costs, information gap, regulatory challenges, workforce and skills challenges, market structure and supply limitations and other non-economic aspects. Moreover, Al-Kodmany (2014) identified challenges in his research, such as cost-effectiveness, finances, policies and codes, technical challenges and split incentives. Additionally, Financial resources, lack of skills and expertise by the project team, policy support, lack of communication and internal leadership were some of the challenges highlighted by Jagarajan *et al.* (2017). The current study's findings are supported by Miller and Byes (2008), who stated that the process of retrofitting an existing building is tremendously troublesome to tenants - the risk to retrofit is taken by the builder owners and funders with the anticipation that the ROI will be realised through higher rentals in the forthcoming years. In addition, the lack of demand for sustainable office buildings can be linked to the limited knowledge by tenants on sustainability and the benefits thereof, as highlighted in the study by Miller and Byes (2008). The study by Khairi, Jaapar and Yahya (2017) identified challenges of retrofitting existing buildings as costly and troublesome – the risk of retrofitting cannot be underestimated and more awareness of GBR needs to be created through training, education and activities; results which support this study. Lack of professional team expertise ranked the lowest; this could be a sign that the participants believed that the professional team has experience in handling retrofitting projects. The result of this study in terms of government regulations is supported by Ismail

and Rogerson (2016), who highlighted that limited government regulations in terms of obligatory GBR are reducing and not promoting the implementation.

5.3.2 Implication of findings

The question aimed to establish challenges that are hindering retrofitting of an existing office building. The results highlighted lack of government incentives as the first challenge in retrofitting office buildings in the CoJ, followed by budget constraints and a longer payback period. These results suggest that stakeholders are aware of the challenges in retrofitting office buildings and are not willing to invest due to the cost uncertainty and longer payback period. More so, the lack of government incentives does not encourage stakeholders to implement retrofitting projects. The private sector is driven by ROI and when regulations don't enforce retrofitting measures and cost certainty is not determined, it will not be possible to achieve the goal of reducing GHG in the short term.

To provide cost certainty to investors and developers, adequate databases and feasibility studies should be developed concerning retrofitting existing office buildings. In addition, tenants should be involved at the planning stage so that their needs can be considered in the retrofitting process and knowledge around the risks and benefits of retrofitting project could be shared and discussed to obtain their buy-in and willingness. Furthermore, disruptions and inconveniences during construction could be minimised with adequate phasing and transition plans.

5.4 RESEARCH OBJECTIVE TWO

RO2 sought to evaluate the benefits of retrofitting existing office buildings in the CoJ. To achieve this objective, the question *Are there benefits of retrofitting existing office buildings in CoJ?* was asked.

RO2 also adopted deductive theoretical reasoning; the research question was converted into a hypothesis to enable testing of the hypothesis against the established green economic theory using the survey data. The survey data was obtained through a five-point Likert-type scale to elicit the extent to which the respondents agreed or disagreed on the variables evaluating the benefits of retrofitting existing office buildings in the CoJ.

H_{02}: There are no benefits to retrofitting existing office buildings in the CoJ.

5.4.1 Findings

The data received from the online questionnaire survey were analysed using sample statistical analysis from SPSS to obtain the mean population score, SD and standard error mean. Results were presented in Tables 11 and 12 in the previous chapter.

The results of this study highlighted improved EE as the first benefit of retrofitting existing office buildings. This result is supported by Jagarajan *et al.* (2017), in terms of enhancement of energy aptitude and by Duran (2018), who identified reducing 'operational energy and carbon emissions' as a main advantage of retrofitting buildings. The result of enhancing the marketability of the buildings is supported by Ashuri and Durmus-Pedini (2010), who indicated in their research that retrofitted buildings have higher occupancy rates and are likely to attract more tenants, therefore, decreasing vacancy periods. Furthermore, the improved level of satisfaction of occupants is supported by a study by Jagarajan *et al.* (2017). Muhammad *et al.* (2017) indicated the productivity of tenants as one of the outcomes of retrofitting. For an organisation to achieve its objective of being profitable, there is a requirement to have a productive team. The authors categorised benefits in terms of environmental, economic and social. According to previous research, employees working in environmentally friendly buildings were found to be more productive.

5.4.2 Implication of findings

This question aimed to establish benefits derived from retrofitting an existing office building. The results highlighted improved EE as the first benefit of retrofitting office buildings in the CoJ followed by enhanced marketability of the buildings and improved building climate control. Various authors have classified retrofit benefits in terms of the triple bottom line which incorporates economic, environmental and social aspects. The results of this study have incorporated all aspects of the benefits highlighted in the literature review. Other authors have argued between the economic factors versus the ecological/societal factors as drivers of green buildings.

5.5 RESEARCH OBJECTIVE THREE

RO3 sought to assess the CSF for retrofitting existing office buildings in the CoJ. To achieve this RO, the question *Are there CSF for retrofitting office buildings in CoJ?* was posed.

RO3 was analysed using deductive theoretical reasoning and thereafter, factors were ranked using the RII. The research question was converted into a hypothesis to enable testing of the hypothesis against the established green economic theory using the survey data. The survey data was obtained through a five-point Likert-type scale to elicit the extent to which the respondents agreed or disagreed with the CSF for retrofitting existing office buildings in the CoJ.

H_{03}: There are no CSF for retrofitting existing office buildings in the CoJ.

5.5.1 Findings

The data received from the online questionnaire survey were analysed using sample statistical analysis from SPSS to obtain the mean population score, SD and standard error mean. Results were presented in Tables 13 and 14 in the previous chapter.

According to Jagarajan (2015), there has been a lack of research on CSF for the successful implementation of GBR projects; this means that there is no prescribed list of factors that are predetermined to confirm that the retrofitting of an existing project has been successful. In addition, all projects are different in terms of their challenges. Khoukhi *et al.* (2020) and Jin *et al.* (2014) emphasised that an all-inclusive integrated approach between stakeholders is required for the successful implementation of retrofitting existing projects. This view has been supported by the *Retrofit 2050* report that outlined eight important considerations for successful implementation. The results of this study highlighted project cost control as the first CSF for retrofitting existing office buildings, followed by communication, efficient planning and regulatory approvals between the municipality and project manager, competency of the project manager and project schedule management. Cost uncertainty has been highlighted in most research as one of the main barriers to retrofitting existing buildings. Miller and Buys (2008) highlighted the need to communicate the cost versus benefits analysis of retrofitting existing buildings

to stakeholders, especially tenants, for their buy-in. The competency of the project manager is supported by Bu *et al.* (2015) under the project management triangle - the responsibility of a project manager is to ensure that the project is completed on time (time), within the budget (cost) and the right quality (quality). Since this RO sought to assess the CSF of retrofitting existing office buildings in the CoJ from the investigated variables, it was important to rank the variables using their RII to determine the weightings of the different variables.

To assess which factor is most critical for retrofitting existing office buildings in the CoJ, the third RO was, further, subject to the RII test and the output (see Table 15) was ranked in ascending order of the population mean. Project cost control ranked the highest while an inclusive urban retrofit agenda ranked lowest. This is in tandem with the ongoing discussion which places cost control as a very important CSF for existing office building retrofitting.

5.5.2 Implication of findings

This question aimed to assess CSFs for retrofitting existing office buildings. The results highlighted project cost control improvement as the first CSF, followed by communication and efficient planning and regulatory approvals between the municipality and project manager. The results suggested that cost plays an important role in the decision of whether to retrofit or not. The financial consideration is done during the pre-planning, at project implementation and during post-completion. The CSF are established by stakeholders for each project due to the unique nature of the project and the complexity thereof. Therefore, CSF cannot be viewed in isolation but rather as a holistic approach with the understanding of stakeholders' needs.

5.6 CHAPTER CONCLUSION

The results received from respondents in terms of the three research questions about evaluating aspects influencing the retrofitting of existing office buildings in the CoJ, including the challenges and benefits as well as CSF for doing so, were presented, and discussed in line with the theoretical underpinning of the study. These results were supported by the literature review. The next chapter will present the conclusion and

recommendations in line with the ROs as identified at the beginning of the study, following discussions of the results in this chapter.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

The three ROs of this study were i) to examine the challenges of retrofitting office buildings, ii) to evaluate the benefits of retrofitting office buildings and iii) to assess the CSF of retrofitting office buildings in the CoJ. This chapter outlines the conclusion and recommendations of the study resulting from the survey findings and the review of the literature.

6.2 RESEARCH OBJECTIVE ONE

RO1 sought to examine the challenges of retrofitting office buildings in the CoJ.

6.2.1 Conclusion

From the review of the literature, the lack of government incentives was identified as the biggest challenge to sustainability; unpredictability and hurdles in terms of government regulations, budget constraints, longer payback period, operations disruptions and constraints, lack of database and inability to trust available information were also identified as challenges to adopt retrofitting existing office buildings. In addition, the authors identified challenges such as capital limitations including longer payback periods, extreme execution costs, information gap, regulatory challenges, workforce and skills challenges, market structure and supply limitations and other non-economic aspects in the literature review.

The study identified the lack of government incentives, budget constraints and longer payback periods as being the three main challenges hampering retrofitting existing office buildings in the CoJ. This is followed by technical challenges, disruption of and inconvenience to the tenant during retrofitting, uncertainty on ROI, lack of databases for retrofitting information, government regulations, building space too small and tenants would rather relocate, lack of benchmarking for office retrofitting and lack of demand for sustainable office buildings. The lack of professional team expertise was not generally considered a challenge. These results are in line with and supported by the literature review.

6.3 RESEARCH OBJECTIVE TWO

RO2 sought to evaluate the benefits of retrofitting existing office buildings in the CoJ.

6.3.1 Conclusion

From the review of literature, enhancement of energy aptitude was identified as reducing 'operational energy and carbon emissions', enhancing the marketability of the buildings, improving the level of satisfaction of occupants, enhancing and protecting the ecosystem and biodiversity supported, improving occupants comforted and health, enhance the environments. The authors categorise benefits in terms of environmental, social, financial, market and industry.

The results of the study identified improved EE, enhanced marketability of the buildings, improved building climate control, reduced energy consumption and reduced operational cost of building as benefits. Further benefits include the improved level of satisfaction of occupants, increased productivity of workers, improved corporate community responsibility, decreased GHG and protect the ecosystem and biodiversity.

6.4 RESEARCH OBJECTIVE THREE

RO3 sought to assess the CSF for retrofitting office buildings in the CoJ.

6.4.1 Conclusion

From the review of the literature, there has been a lack of research on CSF for the successful implementation of GBR projects - this means that there is no prescribed list of factors that are predetermined to confirm that the retrofitting of an existing project has been successful, according to Jagarajan (2015). The review of the literature also suggests that each project team establishes its CSF as all projects are different in their challenges.

The results of the study identified project cost control as being a major criterion for office building retrofitting in the CoJ. This is followed by communication, efficient planning and regulatory approvals between the municipality and project manager, project schedule management, competency of the project manager, teamwork among the project, internal leadership, integrated stakeholder approach, project information management, effective partnerships between private and public sectors and an inclusive urban retrofit agenda.

6.5 RESEARCH CONCLUSION

The review of the literature has identified challenges affecting retrofitting of existing office buildings. It has also identified benefits and CSF in retrofitting existing office buildings. The results obtained from the study identified budget constraints, lack of government incentive, longer payback periods, disruption of and inconvenience to the tenant during retrofitting and uncertainty on ROI as being the five main challenges hampering retrofitting the existing office buildings in CoJ. These results are supported by the review of the literature. In addition, the results of the study found improved EE, enhanced marketability of the buildings, improved building climate control, reduced energy consumption and reduced operational cost of building as the five main benefits of retrofitting existing office buildings. These results are supported by the review of the literature.

Lastly, from the review of the literature, it was established that there has been a lack of research on CSF for the successful implementation of GBR projects, meaning that there is no prescribed list of factors that are predetermined to confirm that the retrofitting of an existing project has been successful. The results of the study identified project cost control as a major criterion for existing office building retrofitting. Other identified criteria were communication, competency of the project manager, efficient planning and regulatory approvals between the municipality and project manager, project schedule management, teamwork among the project, internal leadership, project information management, integrated stakeholder approach, effective partnerships between private and public sectors and an inclusive urban retrofit agenda. These results are supported by the review of the literature.

This study was deductive research and was therefore not allowed to make alterations to the green economic theory using the findings from this study. However, the entire research was viewed through the lens of the green economic theoretical framework.

6.6 RECOMMENDATIONS

SA has been identified as one of the leading emitters of GHG and accounts for 65% of the pollution of the African continent (SA, 2013 as cited by Tongwane *et al.*, 2016). The rate of GHG emission, which is majorly from electricity generation, has continued to grow

over the years. In order to protect our future, the current trend of GHG, particularly from the built environment, must not be allowed to continue. As such, the recommendations of this study are as follows:

- Engagements between various stakeholders should be encouraged in retrofitting projects;
- Cost benefits analysis should be done on retrofitting projects to stimulate investment;
- CSF are to be determined at the beginning of retrofitting projects;
- Changes in government regulations and policies should be reviewed to incentivise retrofitting projects;
- Tenants' inputs are to be obtained at the beginning of projects;
- Public and private sector collaborations are required to create an all-inclusive approach;
- More information must be available about retrofitting initiative; and
- Tertiary curriculum for the built environment to include training and information on sustainability by promoting retrofitting project initiatives.

6.7 AREAS FOR FURTHER STUDIES

Several concerns come to mind in suggesting areas for further studies in line with the current study:

- Studies must be carried out on the reasons why the government is not incentivising the retrofitting of existing office buildings to enable energy conservation, especially with the current energy crises in SA;
- A mixed method study to elicit the opinions and perceptions of major stakeholders in office building project management should also be considered in the future; and
- Government regulations on future office building development and the need for sustainability concerns to be incorporated is also an area of research that needs attention.

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APPENDICES

APPENDIX A: CONSENT FOR PARTICIPATING

Dear Research Participant,

My name is Nathalie Bamoni Katumba, a student in Master of Business Administration (MBA) at the Wits Business School.

You are kindly invited to anonymously participate in a survey as part of my Applied Research Project (ARP) entitled: An Assessment of Retrofitting of Office Buildings in the City of Johannesburg, South Africa.

I am looking for participants who are graduate professionals who manage, design or retrofit office buildings and who have more than one year of working experience.

You will require approximately 5 - 10 minutes to complete the questionnaire. Please note that all responses and personal information will be confidential.

Your involvement in this survey is completely voluntary thus by continuing to complete the survey will be deemed as permission to participate.

Thank you very much in advance for your participation in this survey.

Your sincerely,

Nathalie Bamoni Katumba

2513148@students.wits.ac.za

APPENDIX B: QUESTIONNAIRE SURVEY

Section A: Background information

This section of the questionnaire refers to background or biographical information. Although we are aware of the sensitivity of the questions in this section, the information will allow us to compare groups of respondents. Once again, we assure you that your response will remain anonymous. Your cooperation is appreciated.

What is your gender?

Male	1
Female	2
Others	3

State your highest educational qualification?

Bachelor Degree	1
Honours Degree	2
Master's Degree	3
MBA	4
PhD/Doctorate Degree	5

What is your level in the organisation?

Junior Management	1
Senior Management	2

Professional Staff	3
Manager Middle Management	4
Director Executive Management	5

How many your years of professional experience do you have?

Less than 12 months	1
1-5 years	2
6-10 years	3
11-15 years	4
16-20 years	5
20 years and above	6

For how long have managed office building projects?

Less than 12 months	1
1-5 years	2
6-10 years	3
11-15 years	4
16-20 years	5
20 years and above	6

Definition of Retrofitting:

Retrofitting is defined as “any kind of upgrade at an existing building that is wholly or partially occupied to improve energy and environmental performance, reduce water use and improve the comfort and quality of the space in terms of natural light, air quality and noise” according to the USGBC.

Section B: Challenges of retrofitting existing office buildings

This section of the questionnaire explores the challenges of retrofitting of office buildings in Johannesburg, South Africa.

To what extent do you agree or disagree that the following are the challenges of retrofitting of office buildings in the City of Johannesburg?

On a scale of 1-5, please indicate whether you agree or disagree with the factors below. 1 – Strongly disagree (SDi); 2 – Disagree (D); 3 – Neutral (N); 4 – Agree (A); and 5 – Strongly agree (SAg).

No	**Challenges of retrofitting**	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
		1	**2**	**3**	**4**	**5**
1	Budget constraints					
2	Technical challenges					
3	Longer payback period					
4	Government regulations					
5	Lack of benchmarking for office retrofitting					
6	Lack of database for retrofitting information					

7	Lack of government incentives					
8	Lack of professional team expertise					
9	Disruption of and inconvenience to the tenant during retrofitting					
10	Lack of demand for sustainable office buildings					
11	Uncertainty on ROI					
12	Building space too small and tenants would rather relocate					

Section C: Benefits of retrofitting

This section of the questionnaire explores the benefits of retrofitting of office buildings in Johannesburg, South Africa.

To what extent do you agree or disagree that the following are the benefits of retrofitting of office buildings in the City of Johannesburg?

On a scale of 1-5, please indicate whether you agree or disagree with the factors below. 1 – Strongly disagree (SDi); 2 – Disagree (D); 3 – Neutral (N); 4 – Agree (A); and 5 – Strongly agree (SAg).

No	**Benefits of retrofitting**	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

		1	2	3	4	5
1	Improved energy efficiency					
2	Reduced operational cost of building					
3	Improved building climate control					
4	Improved corporate community responsibility					
5	Improved level of satisfaction of occupants					
6	Enhanced marketability of the buildings					
7	Protects the ecosystem and biodiversity					
8	Increased productivity of workers					
9	Decreased greenhouse gas emissions					
10	Reduced energy consumption					

Section D: Critical success factors of retrofitting

This section of the questionnaire explores the critical success factors for retrofitting of office buildings in Johannesburg, South Africa.

To what extent do you agree or disagree that the following are the critical success factor for the retrofitting of office buildings in the City of Johannesburg?

On a scale of 1-5, please indicate whether you agree or disagree with the factors below. 1 – Strongly disagree (SDi); 2 – Disagree (D); 3 – Neutral (N); 4 – Agree (A); and 5 – Strongly agree (SAg).

No	**Critical Success factors of retrofitting**	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
		1	2	3	4	5
1	Project schedule management					
2	Project information management					
3	Project cost control					
4	Efficient planning and regulatory approvals between municipality and project manager					
5	Effective partnerships between private and public sectors					
6	Integrated stakeholder approach					
7	An inclusive urban retrofit agenda					
8	Teamwork among the project members					

9	Competency of the project manager					
10	Communication					
11	Internal leadership					

Thank you for taking your time to complete this questionnaire.