

An analysis of challenges influencing the adoption of green retrofitting in existing buildings in South Africa

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Abstract

Purpose – As the world grapples with the challenges of climate change, the necessity to improve the energy efficiency and sustainability of existing building stock has become increasingly urgent. This has made green retrofitting an important strategy for existing buildings. Despite its potential environmental and socioeconomic benefits, the adoption of green retrofitting practices remains limited, particularly in developing countries. This study investigates the key challenges hindering the widespread implementation of green retrofitting in South Africa's existing building stock. Africa's existing building stock.

Design/methodology/approach – The quantitative research approach was adopted in the study. Through a scoping literature review complemented by a survey, primary data were collected by administering questionnaires to randomly selected professionals in the South African construction industry. Thereafter, descriptive and inferential statistics were computed from the analysis of the data.

Findings – The research identifies critical challenges, including a lack of awareness regarding the benefits of green retrofit project implementation by clients, a lack of incentives to promote the adoption of green retrofitting of existing buildings, extra costs for transportation of imported materials and a lack of training regarding green retrofitting initiatives among built environment professionals (BEPs). Furthermore, the non-parametric test revealed that there is no significant difference regarding the challenges of green retrofitting of existing buildings across the different built environment professions.

Originality/value – The findings highlight the need for targeted capacity building initiatives, increased public and private sector collaboration, and an integrated policy framework to facilitate the transition to sustainable building. The study provides invaluable insights for industry stakeholders aiming to promote green retrofitting.

Keywords Challenges, Energy efficiency, Existing buildings, Green retrofitting, South Africa, Sustainability

Paper type Research article

1. Introduction

As the global community ramps up efforts to combat climate change and minimise carbon emissions, the built environment has come under increased scrutiny. The built environment contributes significantly to global energy consumption (Ebekoziem *et al.*, 2022) and continues to be a major source of greenhouse gas emissions, making it a critical focus in the pursuit of sustainable development. According to a report compiled by the [United Nations Environment Programme \(UNEP\)](#) and the [Global Alliance for Buildings and Construction \(GlobalABC\)](#) (2024), in 2023, the building and construction sector's emissions were 34%, while energy consumption accounted for approximately 34% of global demand. This is corroborated by [Goestiawan and Anastasia \(2025\)](#), who reveal that the construction industry alone contributes a staggering 39% of gas emissions, underscoring the urgent need for green innovation to

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mitigate their adverse impacts. Sub-Saharan Africa is no exception, since it has its own set of issues in this area. According to [El-Bouayady and Radoine \(2023\)](#), while rising urbanisation and infrastructure development present opportunities for long-term transformation, [Mosner-Ansong et al. \(2024\)](#) highlight that the majority of existing buildings in Africa are energy inefficient. As building operations continue to be a major source of emissions, the need to address climate change intensifies. According to [de Oliveira et al. \(2024\)](#), green retrofitting, which involves upgrading existing buildings with environmentally friendly technologies and practices, has emerged as an important technique for reducing environmental impacts, improving energy efficiency and improving occupant well-being. Nonetheless, the adoption of green retrofitting faces numerous challenges that impede its widespread implementation globally, particularly in existing buildings, which account for a significant share of the building stock. Generally, impediments such as high upfront costs, lack of financial incentives, limited technical expertise and fragmented regulations continue to slow down retrofitting efforts ([Liu et al., 2020](#); [Dauda and Ajayi, 2022](#); [Amoah and Smith, 2024](#)). On the one hand, [Dauda and Ajayi \(2022\)](#) contend that in developed countries, building owners struggle with the complexities of retrofitting aging facilities while ensuring operational continuity. On the other hand, in a developing country context, these issues are exacerbated by weak legislative frameworks and limited access to green technologies and financing ([Jagarajan et al., 2017](#)).

The concept of green building has been established for decades in many nations; nevertheless, the growth prospects in most countries have been slightly sluggish ([Abdulsalam et al., 2024](#)). This is influenced by various barriers such as inadequate communication by GB teams, lack of registered green building specialists, lack of support and enforcement from the government and high initial cost ([Eze et al., 2023](#)). The authors [Eze et al. \(2023\)](#) further highlighted other critical barriers, which include: uncertainty and inadequate knowledge of green building, lack of building codes and regulations and poor relationships amongst stakeholders in Singapore and Australia. Similarly, in Ghana and other developing countries, resistance to change, technical constraints, financial constraints, lack of institutional and legislative barriers, availability of green material in the market, inadequate knowledge and technical expertise were listed as critical barriers influencing the slow uptake of green retrofitting ([Anzagira et al., 2024](#)). In the South African construction industry, the situation reflects both global and regional trends, coupled with additional context-specific challenges. The country's aging building stock, coupled with ongoing energy insecurity, highlights the urgent need for energy-efficient retrofits. However, adoption remains low due to the inadequacy of knowledge from various stakeholders, limited access to green financing, inconsistent policy support, and a general lack of awareness and technical capacity among stakeholders ([Amoah and Smith, 2024](#); [Oguntona et al., 2019](#)). For instance, [Amoah and Smith \(2024\)](#) posit that personnel within the infrastructure directorate in the public sector are perceived to be lacking the technical expertise to manage and mitigate the consumption of water and energy through the adoption of green retrofitting. Despite national efforts such as the Green Building Council of South Africa's (GBCSA's) initiatives, such as developing the existing building performance rating) and inclusion of energy efficiency in building codes, such as SANS 10400X ([Greencape Market Intelligence \(GMI\) Report, 2014](#)), practical implementation is slow and often limited to large commercial or government buildings. Be that as it may, [Ojelabi et al. \(2024\)](#) postulated that there is a noticeable gap in recognising the significance of embracing green retrofit initiatives within government departments, particularly among senior management. Consequently, this has led to a shortfall in both mandates and funding allocated for implementing these sustainable features ([Bertone et al., 2018](#)). There is a knowledge deficiency and lack of technical experience among government personnel for developing robust retrofit and as a result of this barrier, there is limited budget allocation for green retrofit project implementation within annual budgeting cycles ([Hanapiah et al., 2022](#)).

Evidently, the lack of commitment from the government in supporting and promoting green retrofitting of existing facilities practices in public sector projects contributes massively to the

slow rate of adoption (Ojelabi *et al.*, 2024). According to the UNEP and GlobalABC (2024), to minimise carbon emissions by 2030, the rate of building energy efficiency retrofits should be tripled by 2030 to achieve a 35% reduction in energy usage. Major emitters must upgrade passive designs and adopt high-performance technologies. Furthermore, emerging economies should target older buildings and enforce mandatory improvements through energy codes and policies.

According to Madushika and Lu (2023), several studies have investigated the implementation of various mechanisms for decarbonising the built environment; however, limited studies have explored the implementation of green retrofitting of existing buildings in developing economies. Madushika and Lu (2023) and Ebekoziem *et al.* (2022) add that when considering specific regions, especially sub-Saharan Africa, research is even more limited. This is corroborated by Okorafor *et al.* (2021) and Amoah and Smith (2024), who contend that retrofitting as an option in the construction industry is still in its infancy in South Africa.

Against this background, this article investigates the multifaceted challenges negatively influencing the adoption of green retrofitting from a South African perspective. By identifying and contextualising these challenges, the study intends to facilitate more targeted policy creation, investment strategies and stakeholder involvement, all of which are required to enable sustainable transformation in the existing building industry.

The construction industry is one of the biggest users of energy and producers of greenhouse gases (GHGs) in the world. Retrofitting existing buildings with green technology is a viable and quick approach to lessen their impact on the environment. It offers a variety of economic benefits, such as reduced energy and water consumption. Even though there are benefits from the adoption of green retrofitting, there are numerous obstacles inhibiting the widespread adoption in both nationally and globally. Therefore, this study contributes to the growing body of knowledge by categorising critical barriers. This study has categorised barriers into four main themes, which include cultural resistance barrier, cost-related barrier, availability of green material and technology, and lack of technical expertise.

Understanding the critical barriers will enable BEPs, government and academia to develop a comprehensive green retrofitting framework that outlines specific guidelines, targets and performance standards for existing buildings. Furthermore, the government can be encouraged to create financial incentives such as tax rebates, grants and low-interest loans, to offset the upfront costs of green retrofitting projects.

2. Literature review

Previous studies that have examined the challenges in terms of promoting the adoption of green retrofitting in existing buildings include those conducted by Amoah and Smith (2024), Iwuanyanwu *et al.* (2024), Madushika and Lu (2023), Jagarajan *et al.* (2017), Bertone *et al.* (2018) and Dauda and Ajayi (2022). Madushika and Lu (2023) investigated green retrofitting in developing economies to propose future research directions in this field. The study revealed that the challenges influencing the adoption of green retrofitting in existing buildings in both developing and developed economies might be categorised into six groups, namely financial, managerial, social, regulatory, information and technological. The author further indicated that financial barriers can be deemed the most frequently reported challenge category in both economies. According to Iwuanyanwu *et al.* (2024), the challenges to green retrofitting in existing buildings can be categorised as technical-related, financial-related, regulatory-related and logistical. The author noted that structurally, integrating new technologies with outdated systems can be complex, while high initial costs and uncertain returns on investment pose financial barriers. In a similar vein, Amoah and Smith (2024) postulate that the key challenges may be classified as the nature of the existing structures, limited knowledge, and high costs involved in the process. Bertone *et al.* (2018) also categorised challenges influencing green retrofit project implementation as knowledge deficiency and lack of technical expertise related. The key challenges identified in the above literature formed the basis for the

subsequent discussion, whereby the challenges are classified as cultural resistance, cost-related, availability of green material and technology, and technical expertise in green retrofitting.

2.1 Cultural resistance barrier

Resistance to change has been noted as one of the foremost barriers to green retrofitting of existing buildings, which is mainly influenced by the lack of demand from clients and stakeholders of construction projects, negatively affecting the uptake of green retrofitting (Ametepey *et al.*, 2015). According to Ametepey *et al.* (2015), historically, the construction industry has resisted change, especially with respect to construction methods and materials used. This resistance results in a lack of demand for sustainable products by clients and stakeholders, which militates against the implementation of green retrofitting (Oguntona *et al.*, 2019). Jagarajan *et al.* (2017) concur that insufficient engagement and cooperation among stakeholders have contributed to limited green retrofitting of existing buildings. Inflexible regulations, difficult validation and certification processes for new technologies and selective authorised lists of technologies are all viewed as factors that can limit the market entry of new retrofit goods (Khairi *et al.*, 2017). Other aspects associated with resistance to change include distrust in new technologies, lack of political will, and existing development norms and standards (Simpheh *et al.*, 2021). A further contributing factor is the prevalence of a traditional mindset and unwillingness to take on perceived risk (Simpheh *et al.*, 2021).

2.2 Cost-related barrier

High initial costs of incorporating green features into existing building retrofits are cited as one of the major disadvantages of slow growth relative thereto, and are often viewed as a crucial factor hampering the adoption of green retrofitting in both developing and developed markets (Marsh *et al.*, 2021). During a study conducted by Dosumu and Aigbavboa (2021), it was argued that even though the initial costs are viewed as being substantially higher than traditional building, savings accrue during the operational lifecycle of the building through reduced utility costs, as well as reduced maintenance. This implies that for the building or facility to be economically sustainable, it should offer monetary savings to occupiers. Hoffman *et al.* (2020) highlight that obtaining green certification could also be substantially higher in terms of cost, due to the time to be granted and is stressful, irrespective of its potential to increase property rental value and reduce operational cost. According to Firoozi *et al.* (2024), despite the benefits derived from the reduced operational costs of green retrofitting, it is perceived that the high initial investment costs could be a deterrent hindering the adoption thereof. Simpheh and Smallwood (2015) contend that there are limited interventions promoting green retrofitting in South Africa, which is mainly influenced by the lack of government incentives, therefore. Simpheh *et al.* (2021) categorise financial-related challenges hindering green retrofitting of existing buildings as insufficient access to funds to pay for the higher initial expenses, potential for financial loss and insufficient market interest, costs associated with the general upkeep, and uncertainty regarding the investment's profitability, as well as increased overall cost.

2.3 Availability of green material and technology

The issue of the unavailability of green materials and technology in the local market is another major challenge faced by contractors. Jagarajan *et al.* (2017) assert that the major barriers impeding stakeholders from implementing green retrofit projects include knowledge deficit in quantifying green development, the absence of established benchmarks and criteria for evaluating green retrofitting, a lack of consensus in the market regarding primary green standards, insufficient performance data relative to retrofitted buildings, limited resources for appraising retrofitted buildings and an unpredictable return on investment. Therefore, this

indicates that the reluctance to transform to emerging building techniques stems from a number of factors, such as feasibility, viability, availability of materials and reliable assessment tool (Shen *et al.*, 2018).

2.4 Technical expertise in green retrofitting

The effective implementation of green retrofitting is hindered by various barriers related to technical expertise, including inexperienced consultants and contractors, insufficient availability of skills and training for green building, a scarcity of proficient local energy experts to provide information and support on green building frameworks, limited retrofit knowledge among commercial building owners, inadequate sustainability understanding and a deficiency of experienced design teams (Jagarajan *et al.*, 2017). Other factors associated with a lack of connections involve ineffective teamwork among professionals, agencies and departments, as well as a lack of knowledge sharing (Simeh *et al.*, 2021). According to Kumar and Tawalare (2021), a lack of knowledge of emerging technologies and a lack of technical expertise in green technologies hinder the growth rate of green retrofitting of existing buildings. This notion concurs with the findings of the study conducted by Dosumu and Aigbavboa (2021), who opine that inadequate knowledge or deficient technical know-how and lack of experience with green material impede the rapid growth of adoption of green retrofitting.

3. Methodology

3.1 Research design

The study adopted a quantitative research approach to investigate the challenges influencing the implementation of green retrofitting in existing buildings. According to Creswell (2014), quantitative research focuses on deductive reasoning procedures to interpret and structure the meanings that can be obtained from data, as deductive reasoning starts with an idea and uses facts to accept or reject the hypothesis. Leedy and Ormrod (2015) opine that deductive reasoning underpins mathematical proofs in mathematics, physics and other fields; it is also highly valuable for formulating research hypotheses and evaluating ideas. Deductive reasoning was employed in analysing perceptions relative to the challenges influencing the adoption of green retrofitting in existing buildings. For the purpose of the research, green retrofitting refers to improvements or renovations made to an existing building aimed at enhancing building efficiency and environmental sustainability (Amoah and Smith, 2024). These upgrades focus on reducing energy consumption, water usage, and boosting the overall comfort and quality of the space, factoring in aspects such as natural light, air quality and noise reduction (Aghimien *et al.*, 2023).

The data obtained from the BEPs has been converted to numbers and hypotheses have been tested. Ghanad (2023) articulates that quantitative data may be analysed using various statistical methods such as percentages, mean, median, mode, standard deviation and inferences about the population from which the sample will be drawn.

3.2 The sources of data

The type of data gathered for addressing the aim of the study consisted of primary and secondary data. The primary data were collected through survey questionnaires distributed to various professionals in the built environment, mainly involved in public sector projects. Regarding secondary data, a review of related literature was conducted from various sources such as journals, conference proceedings, textbooks, reports and theses. The Nelson Mandela University library provided access to online databases like Access Engineering, Emerald and EBSCOhost.

3.3 Sampling procedure and size

The study adopted probability sampling through stratified random selection for the collection of data from the BEPs relating to the extent and perception towards the implementation of

green retrofitting. Stratified random sampling allows for equal representation of each of the identified population groups (Leedy and Ormrod, 2015). Stratified random sampling is the most appropriate sampling technique when the strata are roughly equal in size in the overall population (Leedy and Ormrod, 2015). According to Ebekoziem *et al.* (2025), a sampling frame consists of the list or source containing all the survey respondents from which a sample is drawn. It is important to highlight that the sampling frame for this study consisted of Green Building Council of South Africa (GBCSA) certified green building consultants, South African Council for the Project and Construction Management Professions (SACPCMP) registered construction project managers and construction managers, South African Council for the Quantity Surveying Profession (SACQSP) registered quantity surveyors, and South African Council for the Architectural Profession (SACAP) registered architects based in South Africa. Considering their background, they were better informed to complete the survey to ensure the data reflects the intended focus.

The list of professionals was accessed from the websites of various built environment councils, such as SACQSP, SACPCMP and SACAP website as shown in Table 1. The Green Building Council South Africa (GBCSA) official membership website was used to draw accredited GBCSA professionals. The permission was requested from gatekeepers to disseminate the online questionnaire to various professionals in the built environment.

Table 2 presents a summary of the sample strata and the corresponding sample sizes. To determine the sample size, the Cochran formula was applied. According to Adhikari (2021), the Cochran formula can be employed to determine the sample size of a quantitative study as expressed below:

$$n = \frac{z^2(p)(q)}{e^2}$$

Where:

- n = sample size
- z = standard error associated with the chosen level of confidence
- p = variability/standard deviation
- $q = 1-p$,
- e = acceptable sample error/margin of error

An assumption of 50% maximum variability or standard deviation, and 95% confidence level with $\pm 8\%$ confidence interval and maximum confidence interval of $\pm 5\%$ as in Adhikari (2021). Therefore, the standard deviation = 0.5, level of confidence = (1.96), $q = (1-0.5) = 0.5$, margin of error $I = 0.08$ and 0.05 (Adhikari, 2021).

Table 1. Population group

Population group	No	Professional body	Source
Green Building Consultant	46	GBCSA	GBCSA (2024)
Quantity Surveyors	215	SACQSP	SACQSP (2023)
Architects	255	SACAP	SACAP (2024)
Construction Project Managers	150	SACPCMP	SACPCMP (2024)
Construction Managers	100	SACPCMP	SACPCMP (2024)
Total	766		

Source(s): Authors' own work

Table 2. Sample strata

Strata	Minimum sample size in each stratum	Maximum sample size in each stratum
Green Building Consultant	$\frac{46}{766} \times 150 = 9$	$\frac{46}{766} \times 384 = 23$
Quantity Surveyors	$\frac{215}{766} \times 150 = 42$	$\frac{215}{766} \times 384 = 108$
Architects	$\frac{255}{766} \times 150 = 50$	$\frac{255}{766} \times 384 = 128$
Construction Project Managers	$\frac{150}{766} \times 150 = 29$	$\frac{150}{766} \times 384 = 75$
Construction Managers	$\frac{100}{766} \times 150 = 20$	$\frac{100}{766} \times 384 = 50$
<i>Total</i>	<i>150</i>	<i>384</i>
Source(s): Authors' own work		

Therefore

$$n = \frac{(1.96)^2(0.5)(0.5)}{0.05^2} = 384.16$$

Evidently, the sample size based on the Cochran formula was 384.

3.4 Survey administration and data collection

The questionnaire survey was administered through a web-based survey, and the data were collected over a period of two months and two weeks. The online questionnaire survey link URL was disseminated to the BEPs through gatekeepers. The email to the gatekeepers included the gatekeeper permission letter explaining the background of the study, aim and purpose, ethical considerations such as confidentiality and procedure for securing data collected and anonymity of participants, stating potential risks such as the estimated time for completing the survey. A timeframe of two calendar months from 01 June to 31 July 2024 was allocated for the survey, and reminders were sent to participants on a weekly basis to ensure the minimum required number is reached. The survey was extended by a further 2 weeks as the minimum required number had not been achieved. The actual cut-off date for data collection was 16 August 2024. A total of 384 potential respondents were selected, of which 174 duly completed and submitted through the survey link, which resulted in a 45.3% response rate. According to Nyakala *et al.* (2021), a response rate of 25% and above is deemed satisfactory in the field of construction management, and therefore, the response rate for this study is considered satisfactory.

3.5 Data analysis

Descriptive and inferential statistics were computed from the analysis of the data collected to address the main research problem of the study. According to Leedy and Ormrod (2015), descriptive statistics provide simple summaries of the data obtained, in the form of mean, mode, median and standard deviations. The descriptive statistics computed for the study included the mean, standard deviations, percentages, which were graphically presented in the form of bar graphs, pie charts, histograms and tables. Inferential statistics enable the researcher to make decisions about the data and are mainly used for testing hypotheses (Leedy and Ormrod, 2015). The study employed inferential statistical analysis to draw inferences about the large population and to examine the validity of the hypotheses by utilising a non-parametric test. It is important to highlight that a normality test was conducted to verify if the data is normally distributed or not. The outcome of the normality test suggested that the data were not normally distributed and therefore Kruskal–Wallis was used to examine the validity

of the hypotheses. This assessment is similar to a parametric one-way ANOVA but offers greater flexibility, convenience, ease of use and powerful (Ostertagova *et al.*, 2014). The Statistical Package for the Social Sciences (SPSS) and Microsoft Excel for Windows were used for capturing and computing the relevant analysis of the data. The IBM SPSS version 26 was adopted to draw inferences about the large population and to examine the validity of the hypothesis through the Kruskal–Wallis test. Internal consistency reliability for all variables of the study was determined using SPSS. Nawi *et al.* (2020) assert that Cronbach’s alpha is one of the highly recommended tools to measure the level of consistency of data. According to Nawi *et al.* (2020), the interpretation of the reliability analysis value can be evaluated based on its strength using the Rule of Thumb as shown in Table 3.

The survey questionnaire consisted of Likert scale-type questions; the responses were initially analysed for reliability through the application of Cronbach’s alpha coefficient test. Table 4 illustrates the internal reliability consistency of challenges influencing green retrofitting of existing buildings:

4. Findings and discussion

4.1 Demographic information

Table 5 presents the respondents’ highest qualification. The study only considered participants with a minimum qualification of a national diploma and therefore 100% of respondents had a

Table 3. Internal reliability consistency (Cronbach’s alpha range)

Cronbach’s alpha coefficient range	Comment/rating
<0.6	Poor
0.6 to < 0.7	Moderate
0.7 to < 0.8	Good
0.8 to < 0.9	Very Good
0.9 >	Excellent

Source(s): Nawi *et al.* (2020)

Table 4. Test of reliability

Factor	Number of items	Cronbach’s alpha coefficient	Comments
Challenges of green retrofitting of existing buildings	17	0.922	Excellent

Source(s): Authors’ own work

Table 5. Respondents’ highest qualification

Qualification	Frequency	Percentage
Diploma	39	22.4
BTech/BSc	85	48.9
BSc (Honours)	37	21.3
MTech/MSc	13	7.5
Total	174	100.0

Source(s): Authors’ own work

tertiary qualification. Out of 174 completed responses, 22.4% had a national diploma, 48.9% had a BTech/BSc degree, 21.3% had a BSc Honours and 7.5% had MTech/MSc.

Table 6 presents the respondents' experience in the construction industry, which ranged from 1–5 years (39.1%), followed by 6–10 years (36.2%), while only 14.9% had 11–15 years. It is notable that only 4.0% had 16–20 years, and 5.8% had >20 years of experience. This indicates that the survey participants had sufficient experience in the built environment, and therefore, they can be deemed informed in terms of the study.

In terms of age, 21–30 years (48.3%) predominated, followed by 31–40 years (39.7%) of the participants (Table 7).

In terms of gender, 62.6% of respondents were male, while 37.4% were female. In terms of employment, 71.0% of respondents worked in private sector organisations, and 29.0% in public sector organisations.

Table 8 indicates that 174 (25.9%) of respondents work for architectural firms, 19.5% work for quantity surveying firms, 14.4% work for implementing agencies/project management firms, 19.5% work for government departments and 20.7% work for building contractors.

4.2 Challenges influencing the implementation of green retrofitting in existing buildings

Table 9 indicates the extent of respondents' agreement with statements related to the challenges impeding the adoption of green retrofitting of existing buildings in terms of percentage responses to a scale of strongly disagree to strongly agree, and mean scores (MSs) between 1.00 and 5.00, the midpoint being 3.00. A total of 17 statements are presented relative to four categories, namely cultural resistance to change (5 No.), cost-related barriers (5 No.), availability of green materials or products (3 No.) and technical expertise and knowledge (4 No.). It is notable that all the MSs are >3.00, which indicates agreement, as opposed to disagreement with the statements.

Table 6. Respondents' experience in the construction industry

Experience range	Frequency	Percentage
1–5 years	68	39.1
6–10 years	63	36.2
11–15 years	26	14.9
16–20 years	7	4.0
>20 years	10	5.8
Total	174	100.0

Source(s): Authors' own work

Table 7. Respondents' age

Age category	Frequency	Percentage
21–30 years	84	48.3
31–40 years	69	39.7
41–50 years	14	8.1
>50 years	7	4.0
Total	174	100.0

Source(s): Authors' own work

Table 8. Respondents' type of organisation

Organisation	Frequency	Percentage
Architectural	45	25.9
Quantity Surveying	34	19.5
Implementing Agent/Project Manager	25	14.4
Government department	34	19.5
Building contractor	36	20.7
Total	174	100.0

Source(s): Authors' own work

Table 9. Extent of agreement with challenges impeding the adoption of green retrofitting of existing buildings

Challenge	Un- sure	Response (%)					Mean score
		Strongly disagree . . .	1	2	3	4	
<i>Cultural resistance to change</i>							
Lack of awareness in terms of the benefits of green retrofit project implementation by client	0.0	0.0	4.0	5.2	39.1	51.7	4.39
Clients fear to implement green retrofit projects due to unproven operational benefits	2.3	0.6	4.0	6.9	42.0	44.3	4.18
Unpredictable performance of emerging technology	1.1	1.7	4.6	6.3	44.8	41.4	4.16
The South African construction industry is reluctant to transform to emerging technologies	0.6	1.7	6.3	8.6	40.8	42.0	4.13
Delays in decision-making to adopt green retrofitting in projects	4.0	1.1	6.9	7.5	37.9	42.5	4.02
<i>Cost-related barrier</i>							
Lack of incentives to promote the adoption of green retrofitting of existing buildings	1.7	1.1	4.6	6.3	51.7	34.5	4.09
Clients are not willing to invest in green retrofit projects due to unproven savings on operational lifecycle	2.3	1.1	8.6	2.9	44.3	40.8	4.08
Green material is a bit expensive compared to traditional building material	4.0	0.6	7.5	6.3	37.9	43.7	4.05
Construction/development costs of incorporating green initiatives are very high compared to traditional building	5.7	1.1	5.7	5.2	37.9	44.3	4.01
Maintenance costs of green retrofitting are very high	4.6	1.7	11.5	6.9	43.7	31.6	3.78
<i>Availability of green material or products</i>							
Extra costs for transportation of imported materials	2.3	0.0	5.7	5.7	40.2	46.0	4.20
Unavailability of certified green material from local markets negatively impact the transition to green retrofitting	3.4	0.6	6.9	4.6	37.9	46.6	4.13
Delivery lead time is a bit lengthy, which prolongs the actual project duration	2.9	0.6	8.6	4.6	46.0	37.4	4.02
<i>Technical expertise and knowledge</i>							
Lack of training regarding green retrofitting initiatives among BEPs	0.0	1.7	2.9	4.0	40.2	51.1	4.36
Lack of experience and knowledge on green retrofit project implementation	0.6	0.6	3.4	4.6	46.6	44.3	4.29
Lack of local contractors with experience on green retrofit projects	0.6	1.1	4.6	2.9	43.7	47.1	4.29
Lack of skills regarding green retrofitting initiatives from BEPs	1.1	1.7	3.4	4.0	46.0	43.7	4.23

Source(s): Authors' own work

With respect to the “cultural resistance to change” category, the MS of “lack of awareness in terms of the benefits of green retrofit project implementation by client” is $4.20 < 5.00$ (4.39), which indicates the concurrence is between agree to strongly agree/strongly agree. The MSs of the remaining four challenges are $3.40 < 4.20$, which indicates that the consensus is between neutral to agree/agree – “client’s fear to implement green retrofit projects due to unproven operational benefits” (4.18), “reluctance due to unpredictable performance of emerging technology” (4.16), the South African construction industry’s reluctance to transform to emerging technologies’ (4.13) and “delays in decision making to adopt green retrofitting in projects” (4.02).

With respect to the cost category, all the MSs are $3.40 < 4.20$, which indicates that the consensus is between neutral to agree/agree – “lack of incentives to promote the adoption of green retrofitting of existing buildings is the highest ranked challenge” (4.09), “clients are not willing to invest in green retrofit projects due to unproven savings on operational lifecycle” (4.08), “green material is a bit expensive compared to traditional building material” (4.05), “construction/development costs of incorporating green initiatives are very high compared to traditional building” (4.01), and “maintenance costs of green retrofitting which are perceived as excessively high” (3.78).

In terms of the category “availability of green materials or products”, all the MSs are $3.40 < 4.20$, which indicates that the consensus is between neutral to agree/agree – “extra costs for transportation of imported materials” (4.20), “unavailability of certified green material from local markets negatively impact the transition to green retrofitting” (4.13) and “delivery lead time is a bit lengthy which prolongs the actual project duration” (4.02).

With respect to the challenges associated with the category “technical expertise and knowledge” all the MSs are $4.20 < 5.00$, which indicates the concurrence is between agree to strongly agree/strongly agree – “lack of training regarding green retrofitting initiatives among BEPs” (4.36), “lack of local contractors with experience on green retrofit projects” (4.29), “lack of experience and knowledge on green retrofit project implementation” (4.29) and “lack of skills regarding green retrofitting initiatives from BEPs” (4.23).

After the descriptive analysis, a non-parametric technique was used to verify whether there is a significant difference regarding the challenges of green retrofitting of existing buildings across the different built environment professions. The normality test was conducted to verify if the data were normally distributed. The Shapiro–Wilk test is regarded as the most suitable test for small sample sizes (<50 samples), but it can also be used for larger sample sizes. The Shapiro–Wilk test has been selected to validate the findings relating to challenges influencing green retrofitting of existing buildings since the sample size exceeds 50. The Shapiro–Wilk test was conducted to determine whether the data were drawn from a normally distributed data. The study population consisted of more than two categories of professionals, and therefore, the Kruskal–Wallis test was adjudged to be the most suitable test for the analysis. The normality test results presented in Table 10 revealed that the data set is not normally distributed as the p -value is less than 0.05 for all variables. Thus, the Kruskal–Wallis test was relevant for further analysis.

4.2.1 Kruskal–Wallis test for challenges influencing implementation of green retrofitting of existing buildings. Table 11 depicts the Kruskal–Wallis test of the challenges impeding the adoption of green retrofitting of existing buildings in relation to the various organisations/firms, such as architectural firms, quantity surveying firms, implementing agents/project managers, government departments and building contractors. The Kruskal–Wallis test was used to check whether there is a significant difference between the challenges and the respondents’ firms. It is apparent that there is no significant difference amongst the various professionals within the firms except one “cultural resistance” variable. Essentially, this indicates that all professionals share the same sentiment regarding the challenges that influence the implementation of green retrofitting of existing buildings.

Table 10. Test of normality on challenges

Challenge	Kolmogorov–Smirnov			Shapiro–wilk		
	Statistic	Df	Sig	Statistic	Df	Sig
<i>Cultural resistance to change</i>						
The South African construction industry is reluctant to transform to emerging technologies	0.275	174	<0.001	0.774	174	<0.001
Lack of awareness in terms of the benefits of green retrofit project implementation by client	0.307	174	<0.001	0.727	174	<0.001
Delays in decision-making to adopt green retrofitting in projects	0.299	174	<0.001	0.740	174	<0.001
Clients fear to implement green retrofit projects due to unproven operational benefits	0.291	174	<0.001	0.712	174	<0.001
Unpredictable performance of emerging technology	0.297	174	<0.001	0.737	174	<0.001
<i>Cost-related barriers</i>						
Construction/development costs of incorporating green initiatives are very high compared to traditional building	0.318	174	<0.001	0.706	174	<0.001
Maintenance costs of green retrofitting are very high	0.319	174	<0.001	0.787	174	<0.001
Lack of incentives to promote the adoption of green retrofitting of existing buildings	0.327	174	<0.001	0.729	174	<0.001
Clients are not willing to invest in green retrofit projects due to unproven savings on operational lifecycle	0.322	174	<0.001	0.728	174	<0.001
Green material is a bit expensive compared to traditional building material	0.301	174	<0.001	0.730	174	<0.001
<i>Availability of green material or products</i>						
Unavailability of certified green material from local markets negatively impact the transition to green retrofitting	0.302	174	<0.001	0.707	174	<0.001
Extra costs for transportation of imported materials	0.288	174	<0.001	0.712	174	<0.001
Delivery lead time is a bit lengthy, which prolongs the actual project duration	0.325	174	<0.001	0.740	174	<0.001
<i>Technical expertise and knowledge</i>						
Lack of skills regarding green retrofitting initiatives from BEPs	0.301	174	<0.001	0.700	174	<0.001
Lack of training regarding green retrofitting initiatives among BEPs	0.289	174	<0.001	0.700	174	<0.001
Lack of local contractors with experience on green retrofit projects	0.279	174	<0.001	0.703	174	<0.001
Lack of experience and knowledge on green retrofit project implementation	0.273	174	<0.001	0.720	174	<0.001
Source(s): Authors' own work						

4.3 Discussion of findings

4.3.1 Challenges influencing the implementation of green retrofitting. The quantitative analysis revealed that there are challenges to the adoption of green retrofitting of existing buildings in the South African construction industry. The investigation also revealed that the challenges influencing the adoption of green retrofitting of existing buildings are classified as cultural resistance to change, cost-related, availability of green materials or products and technical expertise and knowledge.

4.3.1.1 Cultural change resistance barrier. The analysis revealed that a lack of awareness in terms of the benefits of green retrofit project implementation by the client was the top-ranked factor related to cultural resistance to change. This finding is in alignment with previous studies undertaken by [Amoah and Smith \(2024\)](#), [Mawed et al. \(2020\)](#) and [Zhao et al. \(2015\)](#).

Table 11. Kruskal–Wallis test–challenges and the profession of respondents

Challenge	Kruskal–Wallis H	Df	Assumption significance	Significant difference
<i>Cultural resistance to change</i>				
The South African construction industry is reluctant to transform to emerging technologies	11.788	4	0.019	Significant
Lack of awareness in terms of the benefits of green retrofit project implementation by client	5.601	4	0.231	Not significant
Delays in decision-making to adopt green retrofitting in projects	4.319	4	0.365	Not significant
Clients fear implementing green retrofit projects due to unproven operational benefits	4.145	4	0.387	Not significant
Unpredictable performance of emerging technology	5.076	4	0.280	Not significant
<i>Cost-related barriers</i>				
Construction/Development costs of incorporating green initiatives are very high compared to traditional building	7.934	4	0.094	Not significant
Maintenance costs of green retrofitting are very high	8.147	4	0.086	Not significant
Lack of incentives to promote the adoption of green retrofitting of existing buildings	2.139	4	0.710	Not significant
Clients are not willing to invest in green retrofit projects due to unproven savings on operational lifecycle	4.366	4	0.359	Not significant
Green material is a bit expensive compared to traditional building material	6.223	4	0.183	Not significant
<i>Availability of green material or products</i>				
Unavailability of certified green material from local markets negatively impact the transition to green retrofitting	7.054	4	0.133	Not significant
Extra costs for transportation of imported materials	6.125	4	0.190	Not significant
Delivery lead time is a bit lengthy, which prolongs the actual project duration	4.992	4	0.288	Not significant
<i>Technical expertise and knowledge</i>				
Lack of skills regarding green retrofitting initiatives from BEPs	8.882	4	0.064	Not significant
Lack of training regarding green retrofitting initiatives among BEPs	7.242	4	0.124	Not significant
Lack of local contractors with experience on green retrofit projects	7.178	4	0.127	Not significant
Lack of experience and knowledge on green retrofit project implementation	3.503	4	0.477	Not significant
Source(s): Authors' own work				

For instance, [Zhao et al. \(2015\)](#) argue that in the property market, most practitioners lack relevant knowledge regarding green technologies and may find it difficult to clearly articulate the tangible and intangible benefits to the clients. [Mawed et al. \(2020\)](#) add that the lack of awareness of the benefits may influence the commitment of clients and other relevant stakeholders in the process of adopting green retrofit. The results revealed that cultural change resistance is mostly influenced by a lack of awareness and understanding from the built environment stakeholders. It is apparent that improving awareness and knowledge sharing among built environment stakeholders and clients is key to promoting a widespread uptake of green retrofitting.

4.3.1.2 Cost-related barrier. With respect to cost-related barriers, the lack of incentives to promote the adoption of green retrofitting of existing buildings emerged as the top-ranked variable. This finding is consistent with the studies of [Mawed et al. \(2020\)](#) and [Oguntona et al. \(2019\)](#), who similarly highlighted the lack of incentives for investors and the lack of personal incentives as major barriers to green retrofitting implementation. For instance, in the UAE, [Mawed et al. \(2020\)](#) state that due to difficult market conditions, banks were more careful in granting funds for green retrofitting initiatives. Hence, the local government should devise funding schemes that can encourage clients to undertake extensive retrofits. The availability and accessibility of funding will augment the transition towards a more energy-efficient and environmentally friendly built environment.

4.3.1.3 Availability of green materials or products. In terms of availability of green materials or products, additional costs for transportation of imported materials were identified as the top-ranked factor. This finding aligns with that of [Amoah and Smith \(2024\)](#) and [Oguntona et al. \(2019\)](#), who revealed that the high investment cost due to unavailability of green materials or products contributes to the slow rate of adoption of green retrofitting. Similarly, [Mawed et al. \(2020\)](#) highlighted the importance of the financial aspect of a retrofit, indicating that return on investment is the first and crucial barrier to undertaking a retrofit. The findings of the study revealed that scarcity and limited availability of green materials or products in the local markets contribute enormously to increased material costs. Consequently, this factor discourages the built environment from adopting green retrofitting. This suggests that the local production and manufacturing of green materials would minimise the costs associated with transportation and ultimately improve the uptake of green retrofitting.

With respect to technical expertise and knowledge, the top-ranked factor was a lack of training regarding green retrofitting initiatives among BEPs. This is akin to the normative literature where [Amoah and Smith \(2024\)](#) divulged that the most significant barrier to green retrofitting is the lack of knowledge among professionals and building contractors who are expected to undertake the green retrofitting assignment. Similarly, a study conducted by [Mawed et al. \(2020\)](#) revealed that there was a lack of skilled and specialised labour in the UAE market for an extensive green retrofit. The challenge was further exacerbated by the limited flexibility of existing building designs, which then required a high level of expertise. However, the capability of the technical team was limited to the implementation of basic energy-saving initiatives in terms of lights and water. [Bertone et al. \(2018\)](#) also categorised challenges influencing green retrofit project implementation as knowledge deficiency and lack of technical expertise-related barriers. Knowledge deficiency and lack of technical expertise in green retrofitting are attributable to a lack of training in terms of continuous professional development and in-house training. This is further exacerbated by a lack of participation in green building-accredited short courses for built environment professionals.

Following the descriptive analysis, a non-parametric technique was adopted to verify whether there is a significant difference regarding the challenges of green retrofitting of existing buildings across the different built environment professions. The Kruskal–Wallis test revealed that there is no significant difference amongst the various professionals within the firms, except for only one variable under cultural resistance. This indicates that all professionals share the same sentiment regarding challenges that influence the implementation of green retrofitting of existing buildings, apart from the factor “The South African construction industry is reluctant to transform to emerging technologies”. This implies that there is a huge need for collaboration between academia, green building specialists and industry through seminars, workshops, and conferences ([Oyewole and Komolafe, 2018](#)). These will inform BEPs and other relevant stakeholders concerning the utility of green retrofitting as a veritable pathway for actualising sustainability futures.

4.4 Social and practical implications

The research contributes to the understanding of the critical factors that contribute to the slow adoption of green retrofitting in the public and the broader built environment community. The implementation of green retrofitting enhances the health and well-being of occupants with increased property value; it also creates opportunities for employment in the local economy. The communal responsibility to embrace eco-friendly practices is further highlighted by the urgent need for a societal transformation in mindsets and behaviours regarding green retrofit practices. Green retrofit project implementation can be improved through continuous public and professional education, fostering a culture towards transformation to green retrofit practices within the building sector. Collaboration among academics, industry, and government may lead to improved attitudes to change, and integrate sustainability into cultural norms and professional ethics. The cost-related barriers could be mitigated through financial incentives and funding mechanisms by local and national government. The study proposes the availability of green materials and products to local markets to reduce costs associated with transportation and improve implementation. The industry should promote cross-disciplinary collaboration and engagement among stakeholders through conferences and training sessions that integrate transfer of knowledge and optimal procedures into the professional culture. These measures will enhance the knowledge and simultaneously accelerate the implementation of green retrofit projects.

4.5 Limitations

While this study provides a comprehensive exploration of green retrofitting in South Africa, it is important to acknowledge the limitations and identify potential areas for future research. The study was primarily focused on the South African construction industry, and the findings and recommendations may not be directly transferable to other African countries. The survey design effectively communicated the “green” criteria to ensure the data reflected the intended focus and the respondent pool consisted of green retrofitting specialists in South Africa. Further research is needed to investigate the unique challenges and opportunities for green retrofitting in different geographical and socio-economic settings. The research relied heavily on quantitative data gathered through a survey questionnaire. While this approach provided valuable insights, quantitative data on the actual energy savings, emissions reductions and financial impacts of green retrofitting projects could strengthen the analysis and support the development of more robust business cases.

4.6 Directions for future research

Future research should also delve deeper into the technological aspects of green retrofitting, exploring innovative materials, building systems and digital tools that can enhance the efficiency and cost-effectiveness of retrofit interventions. Furthermore, studies on the social and behavioural aspects of green retrofitting, such as occupant engagement and acceptance, can provide important insights to improve the overall success of these initiatives. Finally, longitudinal studies that track the long-term performance and sustainability of green retrofitted buildings would be invaluable in understanding the real-world impacts and informing future decision-making processes.

5. Conclusions and recommendations

The urgent need to minimise GHG emissions and improve energy efficiency has made green retrofitting an important strategy for existing buildings, particularly in developing countries. Despite its potential environmental and socio-economic benefits, the adoption of green retrofitting practices remains limited. This study investigated the key challenges hindering the widespread implementation of green retrofitting in South Africa’s existing building stock. The mean ranking technique was used to rank the challenges influencing the implementation of

green retrofitting in existing buildings in a hierarchical order. Subsequently, the Kruskal–Wallis test was adopted to check whether there is a significant difference between the challenges and the profession or occupation of the respondents. The study’s in-depth analysis has revealed several important insights regarding the state of green retrofitting in the South African construction industry. Firstly, the research determined that the implementation of green retrofitting in existing buildings is still in its nascent stage, with limited adoption and a lack of a comprehensive framework to guide the process. While a few successful pilot projects have been undertaken, the practice remains isolated and lacks widespread integration into the broader building sector. The descriptive statistics technique revealed that in terms of cultural change resistance, the lack of awareness in terms of the benefits of green retrofit project implementation by client, clients fear to implement green retrofit projects due to unproven operational benefits and unpredictable performance of emerging technology were the top-ranked factors. The results divulged that higher initial costs, availability of green materials and technical expertise and knowledge are other major challenges hindering implementation of green retrofitting.

Furthermore, the Kruskal–Wallis results revealed that there is no significant difference regarding the challenges of green retrofitting of existing buildings across the different built environment professions, apart from the factor “The South African construction industry is reluctant to transform to emerging technologies”.

To overcome the challenges influencing the implementation of green retrofitting in existing buildings, the following interventions are recommended:

- (1) Financial incentives and funding mechanisms: National government should introduce tax rebates, grants and low-interest loans specifically for green retrofitting projects. These financial incentives can help offset the initial costs and make retrofitting more attractive to building owners;
- (2) Streamlined permitting process: Simplifying and expediting the approval process for green retrofitting projects can reduce bureaucratic hurdles. Implementing a fast-track system for sustainable retrofits can encourage more building owners to undertake such projects;
- (3) Address skills shortages: Developing targeted vocational programmes and apprenticeships in green retrofitting can help address the lack of skilled professionals in the field. Collaboration with local educational institutions can ensure a steady supply of qualified workers;
- (4) Improve access to information: Creating a centralised online platform that provides comprehensive information on green retrofitting techniques, technologies and best practices can help overcome knowledge barriers. This resource should be easily accessible to all stakeholders, and
- (5) Develop solutions for heritage buildings: Establishing guidelines and techniques for retrofitting heritage buildings while preserving their historical significance is crucial. This can involve collaborating with conservation experts to develop sensitive retrofitting approaches.

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