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Evaluation of Sustainable Building Technologies Adoption in Housing Construction Across Socio-Economic Contexts in Cape Town, South Africa

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Abstract

This research aims to evaluate adoption patterns and key factors influencing the adoption of innovative sustainable building materials in housing across socio-economic contexts in Cape Town, South Africa, to identify targeted interventions that promote equitable access. A mixed-methods approach was used to collect data through semi-structured interviews and survey questionnaires, distributed randomly to Cape Town residents and purposively to professionals working on housing construction projects. The collected data were analysed using descriptive, thematic, and inferential statistical techniques. The study found that most respondents from both classes were aware of sustainable building technologies and materials and perceived that environmentally friendly building materials reduce the environmental impact of construction. The majority of low-income respondents lack access to government assistance and other financial resources compared to middle- and high-income respondents. Both groups utilise recycled materials more often than not. No significant differences were found in the main variables influencing respondents' choices regarding the use of sustainable building materials across the middle- and lower-class groups. In South Africa, the adoption of sustainable building practices is impeded by socio-economic constraints, technological limitations, economic barriers, and insufficient awareness. This study advances knowledge of how economic circumstances affect, at different levels, the use of sustainable building materials and technology in housing construction. The study recommends that governments and financial institutions launch initiatives, such as training and financial incentives, to equip stakeholders with the information they need to increase the likelihood of adopting sustainable practices.

Keywords: Environmental impact, Housing, Income level, Sustainable building technologies, South Africa.

1. Introduction

The construction sector is a major contributor to global environmental degradation, driving urgent calls for sustainable practices, particularly in rapidly urbanising regions like South Africa. This study offers a thorough contextual overview of the topic, highlighting the major variables influencing the uptake of sustainable building materials and technologies, illuminating inequalities, and suggesting tactics to foster more equitable access to sustainable housing options.

The adoption patterns of sustainable building materials and technologies in housing construction vary significantly across different socio-economic contexts, influenced by a multitude of factors (Eze *et al.*, 2021). Economic and socio-cultural contexts are particularly pivotal in shaping the acceptance of sustainable housing technologies (Okitasari *et al.*, 2022). These socio-economic contexts include a wide range of social and economic conditions that influence housing construction, including cost considerations, access to information and education, regulatory environment, cultural factors, infrastructure and resources, and climate change impacts.

Several other variables significantly influence adoption

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trends, in addition to socio-economic factors. According to Khudzari *et al.* (2021), these variables include perceptions of risk and uncertainty around new technologies, the accessibility and availability of sustainable building materials and technologies, technical elements such as building systems and construction techniques, customer preferences, and market demand. Understanding how these factors interact is crucial to formulating strategies that effectively promote the broad adoption of sustainable building practices in the industry. By addressing the imbalance between the knowledge of sustainable materials and technologies and their affordability, this study seeks to provide insights into ways to encourage more equitable and sustainable practices in the construction sector. Sustainable building materials are carefully selected resources that minimise environmental impact while simultaneously promoting social and economic well-being (Okogwu *et al.,* 2023). Moghayedi *et al.* (2022) and Afanasyeva *et al.* (2020) emphasised the substantial influence of enablers and legal standards on the adoption of sustainable practices in housing developments. This influence, in turn, has implications for socio-economic accessibility, shaping the extent to which sustainable housing solutions are accessible to different segments of society. According to Turcotte and Geiser (2015), sustainable housing development has three principles that serve as a definitional tool, meaning it must address environmental, economic, and social factors to be deemed truly sustainable (Shama and Motlak, 2019). This suggests the need for integrated measures that not only reduce environmental effects but also improve cost-effectiveness, equity, and social welfare.

Housing construction is a fundamental aspect of societal development, yet conventional practices often result in environmental degradation and social inequities (Kennedy *et al.*, 2009). Historical analyses show that resource-intensive building practices have repeatedly caused environmental damage and economic inequality (Kennedy et al., 2009). According to Wang et al. (2018) and AlSanad (2015), buildings and the construction sector utilise substantial resources worldwide and have a significant impact on the environment, leading to high energy use and greenhouse gas emissions. According to Kennedy et al. (2009), the housing sector accounts for up to 40% of overall energy consumption. It generates roughly one-third of greenhouse gas emissions across several stages, including the extraction, processing, manufacturing, transportation, construction, and building operation.

Sustainable construction is a strategy to achieve sustainable development and address environmental challenges posed by population growth and increased consumption (Alabi and Fapohunda, 2021). Recent decades have witnessed a growing emphasis on sustainability in the built environment, catalysed by concerns over climate change and resource depletion (Kennedy *et al.*, 2009). Therefore, governments and individuals must find innovative alternatives for sustainable development, and as a result, most countries are working to implement sustainable construction practices to reduce environmental impacts (Alabi and Fapohunda, 2021). Wang *et al.* (2018) noted that Sustainable development, particularly through green building practices and innovative building materials, has emerged as a solution to these challenges, promoting eco-friendly materials and resource-efficient construction. Green Building Technologies and Sustainable Building Materials also play a key role in improving energy efficiency and environmental performance. Building owners must effectively integrate these practices into architectural design to transform traditional buildings into sustainable structures and advance the sustainable building industry (Wang *et al.*, 2018). However, promoting these sustainable practices faces obstacles, especially in developing countries where traditional building practices dominate (AlSanad, 2015).

The adoption of innovative sustainable building materials and technologies in housing construction across socio-economic contexts presents a significant challenge, marked by disparities in adoption rates and accessibility (Khudzari *et al.*, 2021). Despite notable advancements in sustainable building practices, various factors contribute to uneven adoption patterns, hindering widespread implementation.

In many communities, the adoption of sustainable building practices is impeded by socio-economic constraints, technological limitations, economic barriers, and insufficient awareness (Marsh *et al.*, 2020). While some regions readily embrace sustainable alternatives, others remain reliant on traditional, resource-intensive construction methods. This imbalance is particularly evident in South Africa and other regions, where disparities exist in both the knowledge and affordability of sustainable building materials and technologies (Marsh *et al.*, 2020). For instance, developers in areas like Malaysia face obstacles in meeting the growing demand for housing while upholding social and ecological responsibility (Abidin, 2010). Developing countries like Nigeria face barriers in adopting sustainable construction practices (Alabi and Fapohunda, 2021). Despite significant progress in researching the uptake of green buildings in developing countries, recent studies reveal a continued gap in understanding the theoretical and contextual factors influencing the adoption of innovative building materials and technologies in Africa (Mushi *et al.*, 2023).

However, despite the growing body of literature on sustainable construction, there remains a significant gap in understanding how socio-economic factors specifically influence the adoption of sustainable building technologies in Cape Town. Previous studies have often focused on either high-income contexts or broad national trends, lacking a nuanced comparison across income groups within a single urban setting. This study addresses this gap by examining how socio-economic disparities in Cape Town, a city marked by profound inequality, affect access to and adoption of sustainable building materials and technologies, and by identifying the main variables influencing adoption rates, the key implementation obstacles, and the targeted interventions needed to advance sustainable practices. By doing so, the study seeks to generate context-specific insights currently missing from the literature and to provide evidence that can help policymakers and industry practitioners promote the broader adoption of sustainable construction methods, while simultaneously supporting socio-economic development and environmental sustainability by bridging the knowledge and affordability gaps.

2. Literature Review

The adverse environmental impacts of the construction industry cannot be overlooked, as it plays a significant role in the country's economic development. Therefore, it is emphasised that sustainability practices must be integrated within construction operations to ensure that the economic development brought by the construction sector is environmentally responsible (Khalid Mehmood Sadar and Ishak, 2024). Sustainable construction, as defined by Yılmaz and Bakış (2015), involves applying sustainable development principles throughout a building's life cycle, from planning and construction to material sourcing, usage, waste management, and demolition. Green building, according to the United States Environmental Protection Agency USEPA, 2016), focuses on environmentally responsible and resource-efficient practices throughout a building's lifespan, offering an alternative to traditional construction methods to reduce negative environmental impacts and combat climate change. The adoption of Green Building Technologies (GBTs) is essential for achieving green building goals (Chan *et al.*, 2018).

A more comprehensive approach to sustainable development is made possible by the adoption of Green Building Technologies (GBTs), which are defined by the World Green Building Council (WGBC) as structures that offer comfort, cost savings, and a reduced environmental impact (Gohari et al., 2024; Ahmad et al., 2019). Since buildings are primarily responsible for energy use and carbon emissions, the construction sector has a significant influence on sustainable development and environmental preservation worldwide. Health problems are caused by pollution and harmful gas emissions from construction activities (Cao et al., 2022).

Huang, (2018) highlighted that the construction industry is the most significant contributor to global carbon dioxide emissions, driven by the materials and methods used in traditional building practices. This sector is a major factor in environmental degradation, posing risks to future generations. Estimates suggest that construction activities contribute to 25% of global deforestation, with additional emissions from industrialised nations accounting for 10%. Emissions include 39% carbon dioxide, 49% sulfur dioxide, and 25% nitrous oxide, with 40% attributed to raw material extraction (Eze *et al.*, 2023). This is primarily due to conventional building methods and materials. Its impact on environmental degradation underscores the need for a shift towards a circular economy approach in construction to mitigate adverse effects (Saha *et al.*, 2021). Addressing environmental challenges and climate change in the construction sector is crucial, as buildings account for a significant share of global energy use and greenhouse gas emissions.

2.1. Importance of Sustainable Construction

According to Yılmaz and Bakış (2015), sustainable construction is important because it integrates sustainable development concepts throughout the building life cycle. Sustainable construction techniques are critical throughout the whole construction process, from raw material sourcing to demolition and waste management. By incorporating these ideas, sustainable construction guarantees that present demands are addressed while preserving future generations' ability to meet their own needs. It adheres to the three pillars of sustainability; environmental, social, and economic by minimising environmental consequences, promoting social fairness, and maintaining economic viability. This strategy is critical for developing resilient, resource-efficient buildings that will have a positive impact on the future.

2.2. Key Principles of Sustainable Construction

The goal of sustainable construction is to reduce the environmental impact of constructing and maintaining structures while simultaneously creating cosy, healthy spaces. Purvis et al. (2019) examined records from the International Union for Conservation of Nature (IUCN) to determine the origins of the three main pillars of sustainability: social, economic, and environmental. The study found that since the beginning, the three pillars have been closely related to the idea of sustainable development. They illustrate the roots of the well-known circles' diagram and the framework that encourages the attainment of the goals of the three systems.

2.2.1. Economic Sustainability

Economic sustainability is the consistent flow of public and private investments, along with the efficient utilisation and management of resources (Yılmaz and Bakış, 2015). They emphasise evaluating economic efficiency on social criteria rather than organisational profitability alone. The study highlights the potential to enhance economic sustainability in the construction sector by improving industry structure and performance. Additionally, the labour-intensive nature of the construction industry can improve the quality of life by creating job opportunities for individuals with lower incomes.

2.2.2. Social Sustainability

Social Sustainability, as defined by Yılmaz and Bakış (2015), emphasises fundamental human rights and freedoms. It involves ensuring access to essential needs like employment, housing, healthcare, education, and cultural opportunities for all individuals over an extended period. In addition, Eizenberg and Jabareen (2017) introduced a conceptual framework for social sustainability aimed at improving individuals' well-being. The framework consists of four interconnected concepts: equity, safety, eco-prosumption, and sustainable urban forms. It highlighted the need for a theoretical foundation in selecting social sustainability indicators, as current practices often lack a clear definition and are influenced by practical considerations and political agendas.

2.2.3. Environmental Sustainability

Environmental sustainability involves leaving the world in a better state for future generations by preserving ecological balance and natural systems (Yılmaz and Bakış, 2015). This responsibility includes decreasing energy and resource consumption, minimising construction waste and energy usage, reducing external pollution and environmental harm, and minimising internal pollution and health risks. Gohari *et al.*, (2024) elaborate on environmental responsibility, highlighting the commitment to minimising the environmental footprint of construction activities by reducing energy consumption, waste generation, and greenhouse gas emissions. By prioritising these strategies, the construction industry can contribute to broader environmental goals such as biodiversity conservation and sustainable resource management.

In response to urgent environmental issues including resource depletion and climate change, the conventional emphasis on cost, time, and quality in construction management is being expanded to incorporate environmental responsibility (Dosumu and Aigbavboa, 2018). In line with international initiatives to combat climate change and resource depletion, incorporating green materials and sustainable practices into construction management can help reduce adverse environmental effects and advance long-term sustainability in built environments. Therefore, promoting sustainable development goals and guaranteeing the prudent use of natural resources depend on construction management placing a high priority on environmental responsibility.

2.3. Sustainable Building Materials and Technologies

The construction industry is adopting sustainable building materials and technology to reduce environmental impact and improve long-term viability (Javaid *et al.*, 2022). Sustainable methods currently transforming South Africa include using innovative materials such as bamboo, precast concrete, cross-laminated timber, and straw bales, as well as incorporating technologies such as BIM and 3-D printing.

2.4. Innovative Materials

In South Africa, the construction industry is changing as more people become aware of environmental issues and look for greener ways to build (Windapo, 2014). With problems like limited resources and climate change, the focus has shifted to materials that can help both the environment and the economy (Korhonen *et al.*, 2018). These materials are influencing how buildings are designed and built, offering a future where both the planet and people benefit (Raji *et al.*, 2015). Bamboo is strong and flexible; precast concrete is durable and efficient; cross-laminated timber is strong and stable; and straw bales offer excellent insulation. Each one is setting new standards for eco-friendly construction, offering access to buildings that are better for the environment, affordable, and fit the growing demand for sustainable living (Korhonen *et al.*, 2018). Thus, shaping a more sustainable and innovative construction.

2.5. Factors Influencing the Adoption of Sustainable Building Materials and Technologies

2.5.1. Socio-economic Classification in Housing Studies

Socio-economic context

Socio-economic context refers to the combination of social and economic factors that affect a range of outcomes, both positively and negatively, including health, well-being, and living standards (Baker, 2014). Common ways to measure socio-economic status include examining an individual's level of education, income, and occupation. Weilenmann *et al.* (2017) emphasise the importance of investigating economic, demographic, and social issues to better understand the situation. According to Khan *et al.* (2014), in construction, these factors are directly linked to the stages of a country's economic growth and impact industry practices. Furthermore, (Bornstein and Bradley, 2014) show that socio-economic factors may affect people's willingness to employ sustainable construction materials and technology, resulting in different adoption patterns.

Income Levels

Albert *et al.*, (2018) used the monthly income of a family of five to distinguish between different socio-economic groups. The study found that income levels can be defined according to multiples of the poverty line, with per-capita income used to differentiate between different socio-economic categories. Households earning less than the official poverty threshold are deemed poor, whereas those earning between the poverty line and twice that amount are classified as low-income but not impoverished. The classification continues with the lower-middle-income group, earning between two and four times the poverty threshold, followed by the middle-middle-income group, earning four to seven times the poverty threshold. Upper-middle- income households earn seven to twelve times the poverty limit. Those earning between twelve and twenty times the poverty line are considered upper-income but not rich, while the rich earn at least twenty times the poverty line. This concept provides a detailed breakdown of income clusters across various socio-economic groups.

Study by Krausmann *et al.*, (2017) states that in the second half of the twentieth century growth in material use was partly driven by rising income and consumption in the industrial world. This means that the largest share of materials has been consumed in high-income industrial countries (Krausmann *et al.*, 2017). It also means that the higher the income, the more likely a household can afford the upfront costs of green technologies, which tend to be higher compared to conventional materials. The availability of disposable income after accounting for basic living expenses can significantly influence a household's ability to invest in sustainability. According to Owen *et al.*, (2018) financial capacity varies widely among households, with some managing to adopt sustainable technologies through government grants or financing programs despite lower income.

Access to Financing and Affordability

According to a research by Owen *et al.*, (2018), the various contexts of finance ecosystems are very local and regional, requiring public sector interventions that are sensitive to variances, particularly across higher and lower-income nations. Regulatory frameworks, geographic locations, and financial histories can all affect access to credit and incentives (Dabla-Norris *et al.*, 2015). This indicates that varying degrees of support are given for the adoption of sustainable materials and technology to the poor, medium, and upper classes. However, a study by Lorek and Spangenberg, (2014) found that there is a lack of clear understanding of the emerging challenges of sustainable practices in the era of scarcity and people became dependent on private funding, even though households can bridge this gap with incentives and subsidies offered by governments.

Educational Level and Awareness

Education plays a significant role in shaping behavioural intention, environmental knowledge, environmental sensitivity, environmental value, perceived behavioural control, and response efficacy (Wang *et al.*, 2018). This is because education not only helps people better understand environmental issues, but it also helps people realise their environmental responsibility. This indicates a positive correlation between education level and a greater comprehension of the economic and environmental advantages of implementing green technologies. More educated households are more proactive in seeking sustainable building solutions, whereas less educated households may have less access to knowledge or prioritise immediate financial needs over long-term environmental benefits.

Geographic Location and Housing Characteristics

Albert *et al.*,(2018) states that middle-income households tend to own their dwelling and in 2015, about 3 in every 4 (74%) middle-income households resided in dwellings that they own. Meanwhile, 23% rented, and 3% were informal settlers staying in a house or lot without the consent of the owner. In a 2017 study, Greyling and Tregenna analysed quality of life by region, primarily comparing income category, race, sex, age, and urban formal, informal, and tribal and farming communities. According to the report, 97% of White people live in formal housing, compared to 70% of African people, and 98% of White people have access to water on their property, compared to 63% of African people.

Stats SA shows that formal dwellings have 77.7% better living conditions. 75 % of the wealthier respondents reported being either satisfied or very satisfied with life while the low-income group selected the lack of income, high costs of living and a shortage of employment opportunities Greyling and Tregenna, (2017). According to McLennan *et al.* (2016), people's first-hand experience of inequality is therefore contoured by the geographical settings in which they live, work, socialise and travel—making those renters or those in informal housing less likely to make such investments due to uncertainty over property rights or future residence. In Malaysia building projects that meet the green building index are given a property tax reduction Agyekum *et al.*, (2022). This means that property owners generally have more freedom and incentive to invest in long-term upgrades such as solar panels, insulation, or eco-friendly materials.

Inequality in housing happens both inside and between demographic groups (Kährik and Pastak, 2023). Due to limited access to ownership, low-income groups particularly those from migrant and minority ethnic backgrounds are more likely to experience subpar housing and live in rental tenures. These disparities in affordability are especially noticeable for young people, low-income households, and private sector renters (Kährik and Pastak, 2023).This shows that all those in more permanent or higher-quality housing are usually more flexible in implementing sustainable practices because they want to invest in quality.

2.5.2. Impact of Socio-Economic Context in Classifying Households in South Africa

Low-Income Households in South Africa

Swilling et al. (2016) claim that South Africa is the world's most unequal society. The majority of low-income South Africans reside in low-cost RDP housing areas, which are primarily occupied by impoverished Black South Africans. According to Shackleton et al. (2018), the majority of the residents in these townships are impoverished Black South Africans who live in a mix of new and ancient housing. Due to poverty, individuals build homes using inexpensive or scavenged materials on abandoned property on the outskirts of towns or on empty land inside cities (Shackleton et al., 2018). In a similar vein, newly arrived migrants in South African towns typically take up vacant land, creating informal housing zones (Pauw et al., 2022). They do this in the hope of being allocated an RDP house (Makole *et al.*, 2022). This proves and shows that low-income housing adoption rates for sustainable materials are low affected by mostly high initial costs and most of the households depend on grants from the government for the cost of living.

Middle-income Households in South Africa

Swilling et al. (2016) claim that South Africa is the world's most unequal society. The majority of low-income South Africans reside in low-cost RDP housing areas, which are primarily occupied by impoverished Black South Africans. According to Shackleton et al. (2018), the majority of the residents in these townships are impoverished Black South Africans who live in a mix of new and ancient housing. Due to poverty, individuals build homes using inexpensive or scavenged materials on abandoned property on the outskirts of towns or on empty land inside cities (Shackleton et al., 2018). In a similar vein, newly arrived migrants in South African towns typically take up vacant land, creating informal housing zones (Pauw et al., 2022). Although the poor are most at risk of poverty in the future, the middle class is also at risk, thus the government must reevaluate its social protection programs and provide RDP homes and social housing for the middle class (Temidayo et al., 2018).

High-Income Households in South Africa

Shackleton *et al.* (2018) found that suburbs ranging from middle to high-income areas are occupied mostly by white South Africans, but now there is an increasing presence of other racial groups. Study by Ward and Shackleton (2016) states that wealthier urban households tend to have high-income-earning jobs, mostly measured by the number of assets and electricity spending. They are also associated with high levels of education, and these households are mostly located in the CBD and town areas of South Africa. According to Tetteh and Amponsah (2020), smart homes contribute to sustainable development. This implies that homeowners who choose smart housing are typically high-income earners who can afford the costs. They have the resources to fall back on alternative energy sources, such as generators and solar energy during load shedding, which people with low incomes cannot afford (Williams *et al.*, 2020). This means that high-income households have enough monetary value and knowledge to have a high adoption rate of sustainable materials.

Conceptual Framework Linking Socio-Economic Factors to Adoption Behaviour

Building on the factors discussed above, this study proposes a conceptual framework that illustrates how socio-economic context influences the adoption of sustainable building materials and technologies. The framework posits that socio-economic status (determined by income, education, and occupation) affects both **access** (to financing, information, and materials) and **motivation** (awareness, perceived benefits, and regulatory incentives). These, in turn, shape adoption behaviour. This model integrates the key variables identified in the literature and provides a structured basis for the empirical investigation in Cape Town.

In summary, the literature underscores that socio-economic factors, particularly income, education, and access to financing, are critical determinants of sustainable technology adoption. However, few studies have empirically compared these factors across income groups within a single, highly unequal urban context like Cape Town. This study builds on this gap by applying a structured socio-economic lens to adoption behaviour.

3. Materials And Methods

Both quantitative and qualitative data were gathered for this study using a mixed-methods approach. Similar studies have employed a quantitative method in isolation, this study attempts to investigate an alternative strategy to mitigate the drawbacks of doing so. A mixed-methods approach allows the study to retain the strengths of the two methods while mitigating the weaknesses each presents when used in isolation (Creswell and Poth, 2016). Mixed methods approach encourages the further refinement of the data beyond the results obtained by either qualitative or quantitative data on their own. It leads to a deeper understanding of the research problem that would not be achieved if a single method were used in isolation.

Figure 1 shows the steps of the research design and reveals that quantitative data were collected first through cross-sectional surveys, followed by qualitative data collection. It was analysed, and the results were used to collect the qualitative data through semi-structured interviews. It is from this compilation that the data presented in this investigation were derived, followed by the discussion, conclusion, and recommendation. (low-income and middle-high income) was used for comparative statistical analysis. The purposive sample

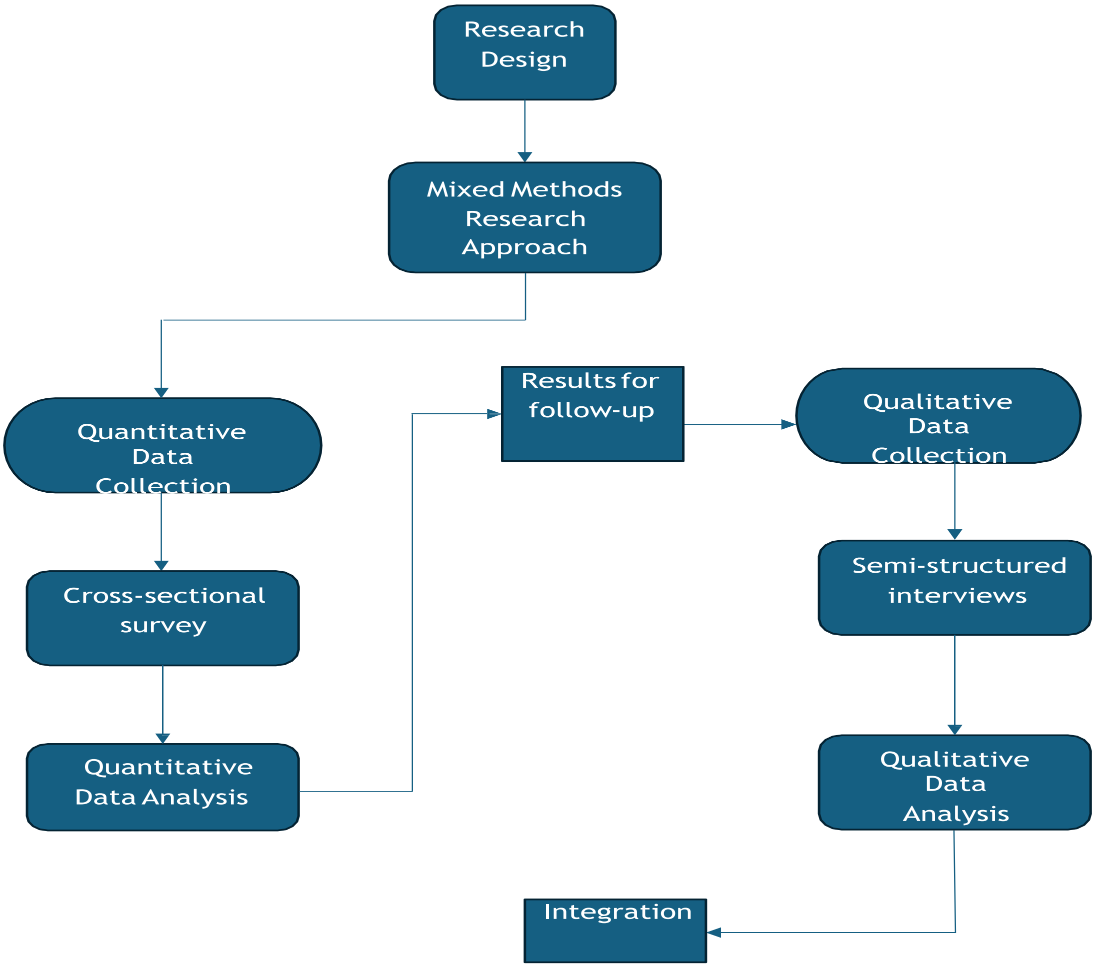

Figure 1: Research design and approach flow diagram

of 15 experts ensured representation from key stakeholder groups (architects, contractors, policymakers) until thematic saturation was reached.

3.1. *Population, Sampling Technique and Data Analysis Method*

Residents of the Cape Town metropolitan region from a range of socio-economic backgrounds were the targeted group for the quantitative data and professionals working on the housing construction projects were the targeted population for the qualitative data. This investigation used probability and non-probability sampling techniques respectively to gather quantitative data and qualitative data.

As instrument, an online survey questionnaire and a probability-based method of sampling was used to allow statistical inference about data to be made (Andrews *et al.*, 2007). Random sampling ensured that all eligible participants had an equal chance of being selected for the study(68 respondents). Further, a purposive sampling technique was used for the semi-structured interviews process(15experts). The rationale for using this technique was to mitigate bias and ensure reliability of the data while the geographical scope of the investigation covered Cape Town, South Africa. For the survey, a minimum sample of 30 per group

The data was analysed using three statistical methods: inferential, thematic, and descriptive statistical analysis. Descriptive statistics were employed to summarise the quantitative data. Conversely, inferential statistics drew conclusions using the sample statistics derived from descriptive statistics. Descriptive statistics were primarily used to characterise the data's measures of central tendency and dispersion. Lastly The NVivo software facilitated the identification, analysis, organisation, description, and reporting of themes in qualitative data through the use of thematic analysis.

Cronbach's alpha a numerical coefficient of reliability with a range between 0 and 1 where values of less than 0.3 are considered unreliable and should not be accepted while values of at least 0.7 suggests that the collected data is appropriate to be used for further analysis as it indicates high reliability. Consequently, the Cronbach's alpha of the survey questionnaire responses for this research scored 0.774, satisfying the condition.

3.2. Ethical Considerations

This study received ethical approval from the University of Cape Town's Ethics Committee. All participants provided informed consent prior to data collection. Survey responses were anonymised, and interview data were kept confidential. Participants were informed of their right to withdraw at any stage without penalty.

4. Findings and Discussion

4.1. Participant Demographic Characteristics

Table 1 below presents the demographic characteristics of respondents, including their level of education, employment status, income levels and home ownership status.

less likely it is to have access to knowledge or to prioritise immediate financial requirements over long-term environmental advantages. This was confirmed by Wang *et al.*, (2018) indicating that education plays a significant role in determining the development of behavioural intention, environmental knowledge, environmental sensitivity, environmental value, perceived behavioural control, and response efficacy. It is based on the fact that education not only helps people better understand environmental issues, but it also helps people realise their environmental responsibility.

4.2. Location of respondents

Table 2. below shows that 38.46% of respondents live in township, 38.46% from the suburban neighbourhood, 12.82% from the urban city centre, and 10.26% from the outskirts.

Table 1: Participant demographic characteristics

Race	low-income Respondent	middle-high income Respondents
Black	*89,66%*	*56,41%*
White	*3,45%*	*25,64%*
Colored	*6,90%*	*17,95%*
Education Level	**low-income Respondent**	**middle-high income Respondents**
High School	*75,86%*	*15,38%*
Bachelors	*10,34%*	*61,54%*
Master's Degree	*3,45%*	*2,56%*
Others	*10,34%*	*20,51%*
Employment Status	**low-income Respondent**	**middle-high income Respondents**
Employed Full-Time	*44,83%*	*87,18%*
Employed Part-Time (Retired)*	*24,14%*	*61,54%*
Unemployed	*17,24%*	*2,56%**
Students	*13,79%*	*5,13%*
Income Level	**low-income Respondent**	**middle-high income Respondents**
R0 to R54 344	*31,03%*	*0%*
R151 727 to R363 930	*68,97%*	*33,33%*
R363 931 to R631 120	-	*35,90%*
R631 121 to R863 906	-	*17,95%*
R863 907 to R1 392 844	-	*12,82%*
Home ownership status	**low-income Respondent**	**middle-high income Respondents**
Built my Own House	*32,14%*	*35,90%*
Bought an Existing Home	*7,14%*	*35,90%*
Rent	*46,43%*	*20,51%*
Other	*14,29%*	*7,69%*

Table 2: Location of Respondents

Outskirts	Township	Urban City Centre	Suburban Neighborhood
10,26%	*38,46%*	*12,82%*	*38,46%*

Table 1. above reveals that a there is positive relationship between education level and a comprehension of the economic and environmental advantages of sustainable building materials. The more educated the household, the greater the probability of being more proactive in seeking sustainable building solutions, whereas the less educated the household, the

Inequality in housing happens both inside and between demographic groupings. Due to limited access to ownership, low-income groups particularly those from migrant and minority ethnic backgrounds are more likely to experience subpar housing and live in rental tenures. These disparities in affordability are especially noticeable for young people, low-income households, and private sector renters (Kährik and Pastak, 2023).Those in more permanent or higher-quality housing are usually more flexible in implementing sustainable practices because they want to invest in quality.

4.3. Nature of regulatory environment, Knowledge of sustainable building materials and Effect of sustainable building materials on reducing environmental impact

According to Table 3, 23 out of 39 respondents in the middle-high incomeand 18 out of 29 respondents in the low-income categories indicated an informal regulatory environment. Overall, both the middle-incomeand upper-class groups mentioned an informal regulatory environment when it comes to the use of sustainable building materials. Additionally, 22 of the 29 respondents from the lower socio-economic classes were aware of sustainable building materials, while 39 of the middle-high school respondents, 34 were aware of sustainable building materials. In general, most respondents from both classes/groups were aware of sustainable building technology and materials. Lastly, the table reveals that 14 low-income respondents strongly agreed, 11 agreed, 2 were neutral, and 2 disputed that using sustainable building materials does assist lessen the environmental impact. It is logical to draw the conclusion that most respondents from both groups think that environmentally friendly building materials can have an effect on reducing environmental impact.

Table 3: Nature of regulatory environment, Knowledge of sustainable building materials and Effect of sustainable building materials on reducing environmental impact

Regulatory Environment	**low-income Respondent**	**middle-high income Respondents**
Informal	*18*	*23*
Formal	*11*	*16*
Knowledge of Sustainability	**low-income Respondent**	**middle-high income Respondents**
No	*7*	*5*
Yes	*22*	*34*
Effect on Reducing Environmental Impact	**low-income Respondent**	**middle-high income Respondents**
Strongly Disagree	-	-
Disagree	*2*	-
Neutral	*2*	*5*
Agree	*11*	*13*
Strongly Agree	*14*	*19*

Results indicate that government policies are important to some extent in fostering awareness of sustainable building materials, alongside incentives. Saha et al. (2021) found that regulatory frameworks on sustainable materials is still lacking in developing countries, and it still needs to be fostered. The study conducted by Luthra et al. (2015) with focused more on sustainable technology states that lack of public interest and litigation are among the barriers identified for promoting sustainable technologies. This shortfall in legal advocacy results in decreased motivation and lower public awareness. To solve this, government should engage more into clear labelling of energy usage on appliances, materials and machinery, along with certification to verify their energy-saving efficiency.

4.4. Use of Sustainable building materials and Frequency of using sustainable materials

Table 4 (See Appendix 1) reveals that 22 out of 39 respondents in the middle-high incomeand 16 out of 29 respondents in the low-income have never utilised solar panels. The findings indicate that although a sizable portion of both groups have used solar panels, the majority have not. Additionally, it reveals that whereas 31 out of 39 respondents from the middle-incomeand upper-class groups have not used green roofs, 24 out of 29 respondents from the lower-class group have not. They equally indicate that both respondent groups use green roofs relatively infrequently. When it comes to recycle materials, 22 out of 39 respondents in the middle-high incomeand 17 out of 29 respondents in the low-income had used them. Both groups utilise recycled materials more often than they do not. Finally, it reveals that although 23 of 39 respondents from the middle-high income group have used rainwater harvesting systems, 17 of 29 respondents from the low-income group have. Demonstrating that more people in both groups utilise rainwater harvesting systems than those who do not.

Regarding the affordability of sustainable building materials, over half of middle-income respondents considered them expensive or extremely expensive, and over half of respondents from lower socio-economic classes did the same. Both categories believe that sustainable building materials are more expensive than conventional ones.

The results are reflection of the change that is happening in South Africa construction industry as more people become aware of environmental issues and look for greener ways to build (Windapo, 2014). With problems like limited resources and climate change, the focus has shifted to materials that can help both the environment and the economy of the country(Korhonen *et al.*, 2018). Sustainable materials have the capacity of influencing how buildings are designed and built, offering a future where both the planet and people benefit (Raji *et al.*, 2015). Each alternative considered is setting new standards for eco-friendly construction, offering access to buildings that are better for the environment, affordable, and fit the growing demand for sustainable living (Korhonen *et al.*, 2018). Thus, shaping a more sustainable world.

These materials shouldn't only be durable but cost-effective and accessible to all for a low impact on the environment. Their versatility makes them great choices for various projects, from homes to commercial buildings. South Africa's commitment to sustainable development is clear in the increasing use of these innovative materials. They help reduce harmful emissions and promote a greener future, even though there are barriers to their adoption.

4.5. Factors influencing the adoption of Sustainable Materials

On the identification of the main variables influencing respondents' choices about the use of sustainable building materials, the RII scores of the factors for middle-incomeand low-income individuals are displayed in tables 5 and 6 below, respectively. The three most important aspects in low-income were initial cost, environmental effect, and long-term cost savings. The three variables that middle-incomeconsidered initial cost, environmental effect, and long-term cost savings revealing that variables influencing adoption in the middle-incomeand lower-class groups were the same.

As the study found, in some instances it costs more to embark on green building projects because green materials are mostly more expensive than their conventional counterparts. Construction cost comparison between 'green' and conventional office buildings prove that green building soft costs are higher than conventional projects due to incremental costs associated with the process of achieving a green building rating (Chan *et al.*, 2017). This involves both application costs as well as additional consulting required under the various rating tools. It is therefore necessary to avail financing options to encouraging the use of sustainable construction practices. Oguntona *et al.* (2019) corroborate with the findings of this investigation indicating that more financing

Table 5: Influencing factors - low-income

Ranking	Influencing factors	RII
1	Cost saving in the long run	0,7
2	Initial cost	0,6
1	Environmental impact	0,7
2	Availability	0,6
3	Government incentives	0,5
2	Awareness and knowledge	0,6
2	Complying with building codes	0,6
2	Aesthetic appeal	0,6
2	Influence of media and adverts	0,6
2	Maintenance and ease of use	0,6

Table 6: Influencing Factors Middle-high class

Ranking	Influencing factors	RII
1	Cost saving in the long run	0,7
1	Initial cost	0,7
1	Environmental impact	0,7
2	Availability	0,6
3	Government incentives	0,5
1	Awareness and knowledge	0,7
2	Complying with building codes	0,6
2	Aesthetic appeal	0,6
3	Influence of media and adverts	0,5
1	Maintenance and ease of use	0,7

alternatives, such as government incentives, can improve the implementation of green technologies.
The findings of this study also demonstrate that environmental conditions have a major impact on the adoption of sustainable building materials. Along the same lines, Ahn et al. (2016) and Ngoy et al. (2023) confirmed that the need to mitigate climate change is one of the main environmental factors driving the adoption of sustainable practices, as building construction and operations significantly contribute to global greenhouse gas emissions.

5. Conclusion

This research aimed to evaluate the factors influencing the adoption of innovative sustainable building materials and technologies in housing construction across various socio-economic contexts. By investigating the relationship between socio-economic factors and the adoption of sustainable practices, the study provided valuable insights into the challenges and opportunities across different settings. The findings confirmed the hypothesis that there is a basic relationship between the adoption of sustainable materials and technologies and the socio-economic context. Key factors impacting adoption patterns include economic incentives, awareness and education, government policies, cultural values, and the availability of resources. The research highlighted significant differences in these factors based on socio-economic status, underscoring the need for targeted strategies that address the unique challenges faced by different communities. In conclusion, this study contributes to the understanding of how socio-economic contexts influence the adoption of sustainable building materials and technologies in housing construction. The insights gained can guide stakeholders such as policymakers, industry professionals, and community organisations in fostering more sustainable practices in the construction sector.

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Appendix 1

Table 4: Use of Sustainable building materials and Frequency of using sustainable materials

Sustainable Building Material		low-income Respondent	middle-high income Respondents
use of solar panels	*Yes*	*13*	*17*
	No	*16*	*22*
use of recycled materials	*Yes*	*12*	*22*
	No	*17*	*17*
use of green roofs	*Yes*	*5*	*8*
	No	*24*	*31*
Use of rainwater harvest	*Yes*	*12*	*23*
	No	*17*	*16*
Frequency of using sustainable materials			
Always		*2*	*2*
Frequently		*6*	*8*
Occassionally		*11*	*16*
Rarely		*7*	*10*
Never		*3*	*3*
Affordability of sustainable building materials			
Very Affordable		*4*	*5*
Affordable		*10*	*8*
They are the same		*3*	*5*
Expensive		*11*	*18*
Very Expensive		*1*	*3*