# Examining the Effectiveness of Green Technology Implementation in Residential Housing Construction Projects: Case Study a of Saloba Ltd Kitwe District Zambia

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**Abstract: The study examined the effectiveness of green technology implementation in residential housing construction projects, using Saloba Ltd in Kitwe District as a case study. It was guided by three objectives: current state of adoption, effects of implementation, and determine challenges. A descriptive research design was employed, targeting employees and stakeholders of Saloba Ltd. Stratified and simple random sampling techniques were applied to ensure fair representation, with a sample size of 50 respondents. Data was collected through structured questionnaires and analyzed using STATA and SPSS. Findings revealed a growing interest in sustainable housing solutions, with modular green housing designs (36%) and affordable off-grid systems (30%) emerging as the most preferred, together accounting for 66% of future adoption trends. However, adoption was constrained, as 36% of respondents viewed the trend as stable and 28% saw it as slowly increasing due to limited awareness and training. Environmental concerns (40%) were identified as the strongest driver of adoption, while material preferences leaned toward locally sourced timber (30%) and eco-friendly roofing materials (28%). Digital tools such as mobile energy-monitoring apps (34%) and BIM (28%) were also highly regarded.**

**The effects of adoption were linked mainly to prestige (34%) and improved health/comfort (32%), while financial savings (18%) and environmental conservation (16%) were secondary. Key challenges included performance uncertainties (26%), limited materials (22%), high costs (14%), regulatory delays (32%), and weak enforcement (30%). In conclusion, meaningful progress in green housing adoption requires stronger policies, better infrastructure, and collaboration among government, policymakers, and construction companies.**

***Keywords:*** *Green Technology, Implementation, Housing, Construction, Projects and Challenges.*

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## I. INTRODUCTION

➢ *Background*

Buildings are among the largest consumers of global resources, accounting for two-thirds of material and energy use, one-quarter of wood harvests, and one-sixth of freshwater withdrawals (Cai et al., 2019). Their impact extends beyond construction sites, affecting air quality, water systems, and communication networks. As the global population grows, adopting sustainable building practices becomes crucial. Sustainable or "green" buildings minimize water and energy consumption, reduce waste, and create healthier living environments through eco-friendly designs, renewable energy use, and efficient land utilization (Nwokoro&Onukube, 2018; Roy & Gupta, 2018). Globally, countries like Indonesia and the United States have made progress—construction contributes 20–30% of total solid waste in Indonesia, while over thirty U.S. states actively promote green building initiatives (Reposa, 2019). Consequently, green buildings are increasingly viewed as cost-effective and environmentally responsible, with over ten thousand commercial green structures already commissioned worldwide (World Architecture News, 2019).

In Africa, rapid urbanization, population growth, and economic expansion intensify demand for housing and sustainable urban planning (De Boeck, 2018). The construction sector, which contributes over 29% to Zambia's GDP (African Economic Outlook, 2020), offers immense development potential yet remains underexplored regarding

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sustainability (Adebayo, 2019). This highlights the need for comprehensive strategies to align construction with environmental goals (Djokoto et al., 2019). A local example is the Flats Construction project in Kitwe by Saloba, which addresses housing shortages through high-density, affordable housing that optimizes land use. The project enhances urban aesthetics, creates employment, and supports infrastructure development. Incorporating green technologies—such as solar systems, rainwater harvesting, and energy-efficient materials—could further enhance sustainability, reduce costs, and position it as a model for environmentally responsible urban housing in Zambia.

➢ *Statement of the Problem*

The effectiveness of green technology implementation in Residential Housing construction projects remains an area of growing concern in Zambia, particularly in Saloba Ltd Kitwe District Zambia.Despite the potential of green technologies to mitigate environmental impacts, such as waste generation, energy consumption, and carbon emissions, the adoption of these technologies in the local construction sector has been limited. Although Zambia has made strides through initiatives like the Zambia Green Jobs Programme (ZGJP) and the construction of green buildings like the Standard Chartered Head Office in Lusaka (UN, 2019), the application of green technologies in construction projects in Kitwe has been slow and inconsistent. One key issue is the high initial capital costs associated with green building materials and technologies, which deters many developers from adopting sustainable practices (Musonda&Mbewe, 2022). Additionally, there is a lack of widespread awareness and knowledge about the benefits of green technologies among local contractors, developers, and the community. This research seeks to investigate the challenges, opportunities, and overall effectiveness of implementing green technology in Kitwe's construction projects to contribute to sustainable urban development.

- *General Objective*

The general objective of the aim of the was to examining the effectiveness of green technology implementation in residential housing construction projects; case study a Saloba Ltd in kitwe district.

- *Specific Objectives*

✓ To determine the current state of green technology adoption in residential housing construction projects.
✓ To identify effects of green technology implementation in residential housing construction projects.
✓ To find out Challenges to Green Technology Adoption in residential housing Construction.

➢ *Research Question*

- What is the current state of green technology adoption in residential housing construction projects?
- What are the effects of implementing green technologies in residential housing construction projects?
- What are the challenges and barriers to adopting green technologies in residential housing construction projects?

➢ *Conceptual Frameworks*

The framework is grounded in the idea that the effectiveness of green technology implementation in construction projects depends on three main dimensions: current adoption status, benefits derived, and challenges faced. These elements are interlinked adoption levels influence the types and magnitude of benefits realized, while challenges act as barriers that can slow or limit adoption. Effectiveness is assessed through measurable indicators such as energy efficiency, cost savings, environmental impact reduction, and stakeholder satisfaction.

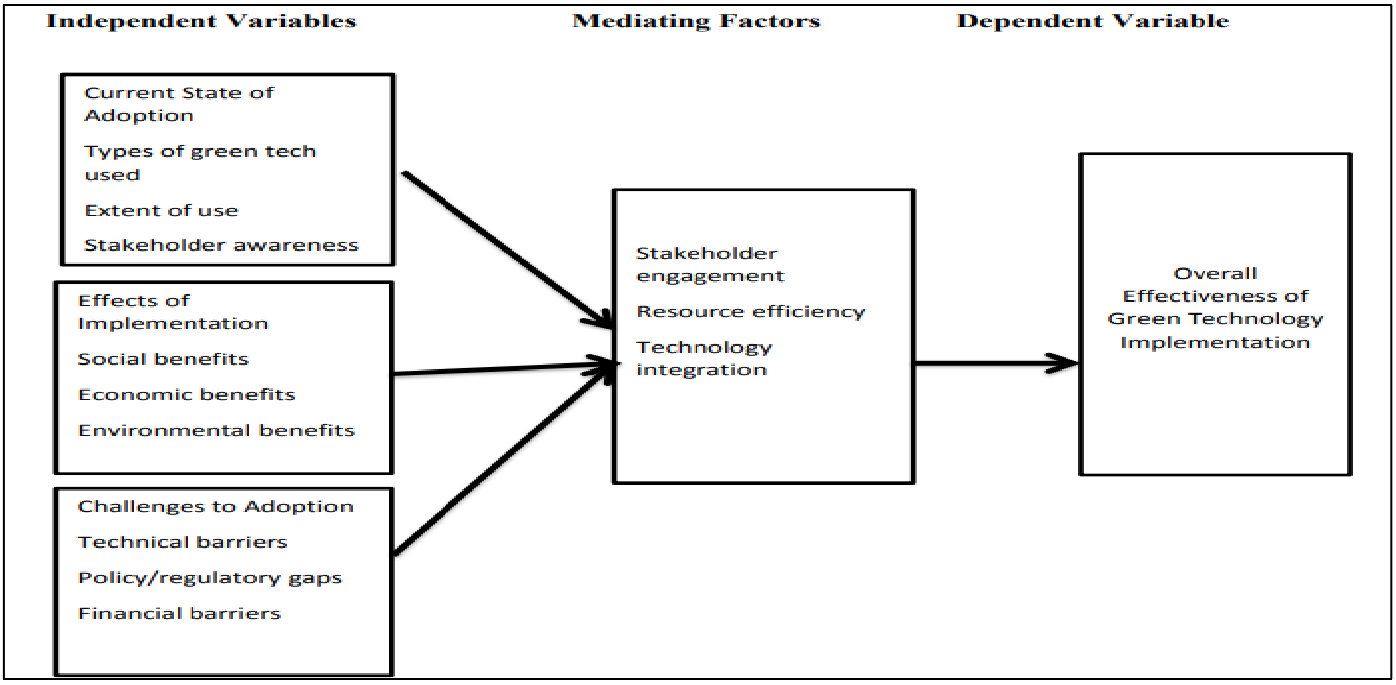


Fig 1 Conceptual Frameworks

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## II. LITERATURE REVIEW

➢ *Current State of Green Technology Adoption in Residential Housing Construction Projects.*

A significant study by Akin and Akin (2022) examined how sustainable practices in the UK real estate industry are influenced by green investments. The research identified key factors such as regulatory frameworks, market demand, financial incentives, corporate responsibility, and technological innovation as crucial in promoting sustainable practices. The findings emphasized the role of green investments, including green bonds, in fostering sustainability within the industry.

Further empirical research by Akin and Akin (2022) explored the impact of green investments on sustainable practices in the UK real estate industry. The study found that factors such as regulatory frameworks, market demand, financial incentives, corporate responsibility, and technological innovation significantly influence the adoption of sustainable practices. The research highlighted the importance of green investments, including green bonds, in promoting sustainability within the sector. Additionally, a study by the UK Green Building Council (2024) assessed the barriers to the adoption of sustainable building materials (SBMs) in construction projects. The research utilized a questionnaire survey to determine the major obstacles hindering the widespread use of SBMs. The findings indicated that factors such as high costs, lack of awareness, and insufficient training among construction professionals were significant barriers to the adoption of sustainable materials. Collectively, these empirical studies underscore the multifaceted nature of green technology adoption in the UK's residential housing sector. While there is a clear trend towards integrating sustainable practices, challenges related to cost, awareness, and training remain prevalent. Addressing these barriers is essential for accelerating the widespread implementation of green technologies in residential construction projects.

A study by Simpeh and Smallwood (2018) identified that despite increased awareness, South Africa lags in green building implementation due to factors like high costs, limited knowledge, and inadequate government support. Similarly, Windapo (2014) found that green building is still in its early stages in South Africa, with rising energy costs and the Green Building Council of South Africa playing pivotal roles in its development. Furthermore, research by Opawole et al. (2024) highlighted that while technologies like Building Information Modelling (BIM) and drones are being explored, their adoption is limited due to high costs and a lack of skilled professionals. Incentives such as economic support, affordable materials, and increased awareness have been proposed to encourage green building adoption. However, the effectiveness of these incentives remains a topic of ongoing research. Overall, while there is a move towards greener construction practices in South Africa, significant challenges remain in achieving widespread adoption.

A significant study by Simwero et al. (2024) assessed the awareness and adoption levels of sustainable construction practices among professionals in Kenya. The research revealed a high awareness rate of 79%, indicating that most industry stakeholders are informed about sustainable practices. However, the adoption rate was slightly lower at 72.3%, suggesting that while knowledge is widespread, its application in projects is still developing. This gap highlights the need for more effective implementation strategies and support systems to translate awareness into practice

Further analysis by Wakhungu (2021) focused on residential developments in Nairobi, identifying key factors influencing the adoption of green building concepts. The study found that developers' perceptions of cost and the lack of incentives were significant barriers. Despite these challenges, the research indicated a growing interest in sustainable designs, especially among developers aiming to meet international standards and attract environmentally conscious buyers

In Zambia, the construction sector has shown remarkable growth over the last three decades, with its GDP contribution increasing from 3.6% in 1995 to 10.9% in 2000, before a slight drop to 10.3% in 2017 (Cheelo&Liebenthal, 2018). This growth signifies increased infrastructure development but also raises concerns over the sector’s environmental sustainability. Empirical studies have shown that, while the Zambian government and industry stakeholders recognize the need for sustainable practices, adoption remains limited due to systemic barriers (Zulu &Muleya, 2017; Dosumu&Aigbavboa, 2018). These barriers include the perceived high costs of green construction technologies (Hwang & Tan, 2012), low client demand (Yin et al., 2018), and inadequate awareness and technical capacity (Shafii, Ali & Othman, 2006; Jacobs, 2015). However, empirical findings in Zambia present a mixed picture. For example, Zulu and Muleya (2017) identified low sustainability awareness among industry players as a significant barrier, while Oke et al. (2019) found that awareness levels were “reasonably fine” among professionals, though this awareness did not necessarily translate into practice. This mismatch aligns with Kibwami and Tutesigensi’s (2016) findings in Uganda, where high awareness of sustainable construction principles did not correspond with widespread implementation, largely due to cost constraints and lack of supportive policy frameworks. The contradictions in Zambian studies highlight a critical empirical gap: while awareness may be improving, the drivers translating awareness into active adoption of green technology remain underexplored. Furthermore, Zambia-specific empirical evidence on the current state of green technology adoption is scarce. Few studies have quantified the proportion of construction projects that integrate technologies such as energy-efficient materials, water recycling systems, solar energy integration, or low-carbon cement alternatives. Where green technologies are adopted, they are often found in donor-funded or high-profile public projects rather than in small-to-medium scale local developments (Zulu &Muleya, 2017; Oke et al., 2019). This reflects broader trends in sub-Saharan Africa, where green construction remains a niche practice, heavily dependent on

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international funding and policy incentives (Ametepey, Aigbavboa&Ansah, 2015).

- *Effects of Green Technology Implementation in Residential Housing Construction Projects.*

The body of literature concerning green building and its associated technologies consistently emphasizes the multiple advantages that these innovations can bring to the construction industry, the environment, and society at large. Geng et al. (2017) highlighted that conventional buildings represent one of the most significant contributors to energy consumption and carbon dioxide (CO) emissions, noting that construction-related products account for approximately 40% of global greenhouse gas emissions. This observation underscores the urgent need to reconsider traditional building practices, as the environmental burden of construction activities is not merely localized but contributes substantially to global climate change. The implications of this are twofold: first, there is a direct environmental necessity for more sustainable construction practices, and second, there is an economic and social rationale for reducing operational costs associated with energy and water consumption in buildings. By mitigating the energy-intensive processes associated with conventional construction, green buildings present a viable solution to these pressing challenges. However, Geng et al.'s study primarily provides a quantitative assessment of emissions without delving into the practical barriers to adopting green technologies, leaving a gap in understanding the implementation challenges within varying socio-economic and geographical contexts.

As documented in "Greening the Construction Industry in Nigeria" by Elizabeth M. et al. (2016), the purpose of this study was to provide an overview of the level of adoption of green/sustainable supply chain management practices in the construction sector in Nigeria, which will help achieve sustainable construction practices that can address both current and future demand (Wu et al., 2019). The study was completed through a questionnaire composed of a number of sections that captured basic demographic information about the respondents along with the topic area of the research. Of the 28 responses received, 13 (or 44.4%) of those surveyed agreed that one of the greatest benefits to adopting green/sustainable supply chain management practices within the Nigerian construction sector is improved sustainability of resources, 11 (or 40.7%) of those surveyed believed it leads to improved quality of products and services delivered in the construction sector, and eight (or 28.6%) of the respondents identified improvements in financial performance and a reduction in risks as another benefit. Additionally, seven (or 25.0%) of the respondents identified stronger compliance with regulatory requirements as a benefit to implementing green/sustainable supply chain management practices, while six (or 21.4%) of the respondents identified enhanced operational efficiency.

The study revealed that Nigerian construction companies are aware of all the benefits associated with the use of GSCM. They are also aware that their suppliers also need to have met the environmental laws and requirements. The conclusion from this study is that the real problem facing Nigerian construction companies is not the creation of laws but the eventual success of it through the Implementation of the Law(s); that is to say, proactive companies implement more environmental practices than what is required by law and the regulations; while reactive companies only seek to comply with what is required by law or the regulations. Therefore, government, regulatory agencies and other professional organizations/associations need to engage in implementing GSCM and support sustainable construction practices in Nigeria. The information gathered in this study provides a valid rationale for the implementation of GSCM practices and reasons for the construction industry in Nigeria to begin adopting GSCM.

As Yang et al. (2017) caution, while the building industry globally is becoming increasingly aware of the advantages of "going green," it is equally important to recognize the unique risks associated with sustainable design, such as uncertain payback periods, limited availability of certified green materials, and potential incompatibility with local construction practices. In Zambia, these risks are compounded by market constraints, including an underdeveloped green materials supply chain and the absence of mandatory national green building codes. Therefore, successful implementation of GBT in Zambia requires a comprehensive approach that considers not only the environmental and economic benefits but also the contextual challenges—ranging from technical capacity building and policy support to financial incentives and risk mitigation strategies—that will influence its long-term adoption and effectiveness.

- *Challenges to Green Technology Adoption in residential housing Construction.*

Many construction professionals in developing countries have traditionally relied on conventional methods and materials and lack exposure to modern green practices. This skills gap often results in improper implementation of GBTs, reducing their efficiency and discouraging further adoption. Chan et al. (2016) emphasize that resistance to change, stemming from a lack of awareness and understanding of the benefits of GBTs, remains a major challenge in promoting sustainable construction. Developers and contractors may perceive green technologies as complicated or technically challenging, leading to reluctance in embracing new methods even when long-term cost savings and environmental benefits are evident. Developed nations, by contrast, have invested heavily in education, training, and professional certification programs to build a competent workforce capable of implementing sustainable construction practices. For example, countries such as the United Kingdom and Australia have integrated sustainability modules into construction management curricula and professional development programs, ensuring that architects, engineers, and contractors possess the necessary skills to design and implement green buildings effectively. Such investments in capacity building are essential in fostering a culture of sustainability and equipping industry professionals with the confidence and competence needed to adopt innovative green solutions.

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In the African context, the discourse surrounding the cost implications of green building mirrors many of the misconceptions observed globally, yet it is further complicated by unique regional economic and infrastructural challenges. According to the National Research Council (2011), public perception often places the cost of green buildings at around 17% higher than conventional construction, a figure that tends to discourage both public and private sector investment in sustainable infrastructure. However, the same study's evidence-based analysis of 146 green buildings revealed that the actual cost premium was far lower—closer to 2% of total design and construction costs. When contextualized for Africa, this finding holds significant relevance because the region's construction sector frequently grapples with limited capital availability, high borrowing costs, and investor caution, making cost perceptions a decisive barrier to innovation adoption. Furthermore, life cycle analyses have consistently shown that, over the lifespan of a green building, energy savings alone can far outweigh the initial 2% premium, resulting in total life cycle savings equivalent to approximately 20% of total construction costs. This aligns with emerging African case studies, such as South Africa's Green Star–rated commercial buildings and Kenya's EDGE-certified housing projects, which report substantial operational cost reductions over time, despite higher up-front investment.

However, in much of Africa, the adoption of green buildings remains hindered by the absence of robust, locally sourced evidence-based data that can convincingly demonstrate the business case for sustainable construction. Without region-specific empirical proof, federal and municipal agency managers often find it challenging to justify high-performance building investment within tight public budgets, especially when competing against urgent infrastructure needs like housing expansion, water supply, and road development. The concept of a "green premium," as described by Dwaikat and Ali (2016), refers to the additional capital typically required to construct a green building compared to a conventional one, and in the African setting, this premium is often amplified by reliance on imported sustainable materials, limited economies of scale, and a shortage of skilled professionals familiar with advanced energy modelling and sustainable design techniques. LEED (2016) highlights that such cost premiums are largely driven by investments in high-performance features, including superior mechanical systems, energy-efficient glazing, sustainable construction materials, advanced building simulations, and third-party certification processes. For African projects, these elements are frequently more expensive due to supply chain constraints, import tariffs, and currency volatility.

In the zambia context, the adoption of green building technologies has been hindered by a complex interplay of economic, policy, and market-related challenges, with Zambia providing a telling example of the prevailing constraints. According to Zhang et al. (2012), one of the most significant barriers to the large-scale implementation of features such as extensive green roofs in Zambia is the increased maintenance cost, which discourages both property developers and building owners from pursuing such innovations. The absence of strong government-led incentives—whether in the form of subsidies, tax rebates, or regulatory advantages—further compounds the problem, creating an environment where sustainable construction is perceived as a high-cost, low-reward venture. In Lusaka, Zheng et al. (2012) examined ten common barriers affecting the development of real estate and facilities management and found that the two most distinct impediments to green building adoption were the high cost of green appliances and the lack of consumer-driven demand. This suggests that beyond supply-side constraints, there is also a weak pull from the market, as potential customers may be unaware of the long-term benefits or may prioritize short-term affordability over environmental performance.

The issue of cost—both initial and ongoing—emerges consistently across African case studies as a critical bottleneck. Higher upfront investment requirements for green technologies, ranging from energy-efficient appliances to sustainable building materials, make them less competitive compared to conventional alternatives. Even when project developers are motivated to incorporate sustainable features, the additional cost burden can deter progress, particularly in contexts where access to affordable financing is limited. Hwang et al. (2015) provide further insight into the economic risks associated with green building projects, noting that one possible reason for cost overruns is their higher susceptibility to project delays compared to traditional developments. Delays often lead to increased labor costs, extended equipment rentals, and postponed revenue streams, exacerbating the financial pressures on developers. This is supported by Hwang and Leong Hwang (2013), who found that 33.33% of green projects experienced delays, in stark contrast to only 17.39% of traditional projects. Such statistics reinforce the perception that green construction carries greater project execution risks, which, in turn, dampens investor confidence and slows adoption rates.

## III. MATHODOLOGY

➢ *Research Design*

The study adopted a mixed-approach descriptive research design to achieve a comprehensive understanding of the research phenomenon. This design integrated both qualitative and quantitative methods, combining contextual insights with statistical analysis. The qualitative approach provided in-depth understanding, while the quantitative approach facilitated numerical data collection and interpretation. As noted by Kothari (2016), descriptive research focuses on identifying and describing characteristics or occurrences within a given situation or group. By merging these methods, the study ensured relevance, accuracy, and depth in addressing its objectives while maintaining efficiency in data collection and analysis.

➢ *Target Population*

The main population of this study consisted of Saloba Ltd construction. The population was finite, with a known number of study participants. Key aspects of this finite population included a defined population size, specific

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characteristics that distinguished the group, and the ability to apply targeted sampling methods. By studying this finite population, the researchers gathered specific insights and drew informed conclusions about the group under investigation.

➢ *Sampling Procedure*

This research employed a survey method, specifically a mixed approach, using two probability sampling techniques: stratified sampling and simple random sampling. Stratified sampling involved dividing the population into distinct subgroups or strata and sampling from each subgroup to ensure adequate representation. Simple random sampling involved selecting participants randomly from the population, giving every individual an equal chance of being chosen, to minimize bias and ensure a representative sample. By combining these techniques, the study aimed to increase the validity and reliability of its findings. As emphasized by Kothari (2016), descriptive studies require adequate safeguards against bias, making probability sampling the most appropriate approach for this research.

➢ *Sample Size Determination*

The participants for the study were drawn from Saloba Ltd, with a sample size of 50 respondents for quantitative data and 10 for qualitative data. The sample size was determined based on the research objectives and design, and participants were selected according to specific criteria to ensure their relevance to the study. This approach allowed for the collection of meaningful insights and the drawing of informed conclusions.

➢ *Data Collection*

The study used a multi-method approach to assess green technology implementation in Saloba Ltd. Data were collected through questionnaires, interviews, and focus group discussions with construction staff, project managers, engineers, and community members. These methods explored the types, adoption levels, benefits, and challenges of green technologies, as well as community perceptions of their environmental, economic, and social impacts. Observational data from ongoing projects validated findings, ensuring comprehensive and reliable insights into green technology adoption in Kitwe's construction sector.

➢ *Data Analysis*

The study employed a descriptive research design using questionnaires as the main data collection tool. Data were coded, tabulated, and analyzed using SPSS for descriptive statistics, while Microsoft Excel generated charts and graphs. Qualitative data from interviews were manually analyzed through content analysis by identifying and categorizing emerging themes and patterns, enabling a deeper understanding of participants' perspectives and experiences.

➢ *Triangulation*

Triangulation was used to validate findings through multiple research methods, including surveys, structured questionnaires, interviews, and focus group discussions. A probability sampling technique was applied to select participants, and data were coded and thematically analyzed. This multi-method approach ensured reliability and provided comprehensive insights into the research phenomenon, with each method revealing different aspects of reality within the study's context.

➢ *Limitation of Study*

The researchers experienced challenges due to the fact that many survey participants did not have the proper knowledge about the formats being used in the survey. Financial limitations restricted the researcher from effectively gathering data, and certain important information was withheld from the researcher because of concerns over confidentiality.

➢ *Ethical Considerations*

Informed consent was obtained from all participants in the study. The participants were informed about the purpose of the study and responded to the questions anonymously; they were free to skip any question they did not feel comfortable answering. Data collection tools were kept securely and confidentially. The information gathered was used solely for the purposes of this academic study. Necessary research authorities were consulted for permission prior to data collection.

## IV. PRESENTATION, INTERPRETATION OF FINDINGS AND DISCUSSION OF THE FINDINGS

➢ *Background Information*

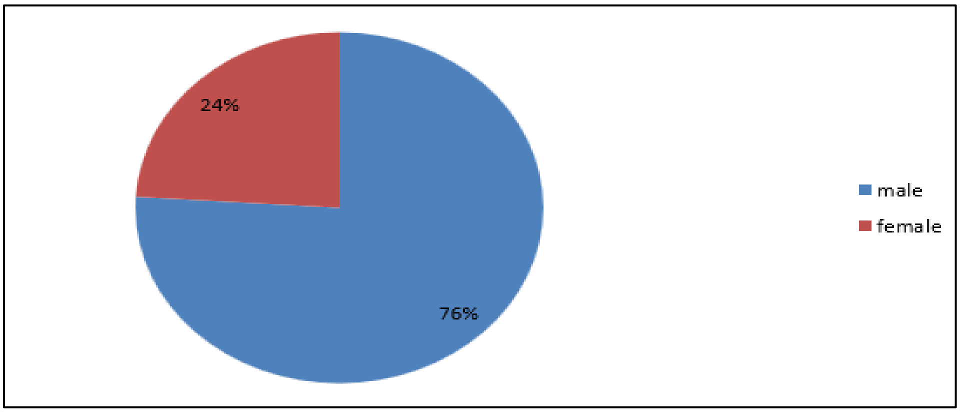


Fig 2 of Sex

The distribution of respondents by sex reveals a notable imbalance, with males dominating the sample. Out of a total of 50 respondents, 38 (76%) identified as male, while 12 (24%) identified as female. This disparity is evident in the cumulative percentage, where females account for only 24% of the sample, and males make up the remaining 76%, resulting in a total of 100% when combined.

Table 1 Age

| | Freq. | Percent |
|---|---|---|
| 35 | 21 | 42.00 |
| 40 | 8 | 16.00 |
| 45 | 9 | 18.00 |
| 50 | 12 | 24.00 |
| Total | 50 | 100.00 |

The age distribution of the respondents shows that the majority (42%) are 35 years old, accounting for 21 individuals in the sample. The remaining respondents are distributed across other age groups, with 16% (8 individuals) being 40 years old, 18% (9 individuals) being 45 years old, and 24% (12 individuals) being 50 years old. The cumulative percentages indicate that 58% of the respondents are either 35 or 40 years old, while 76% are 45 years old or younger.

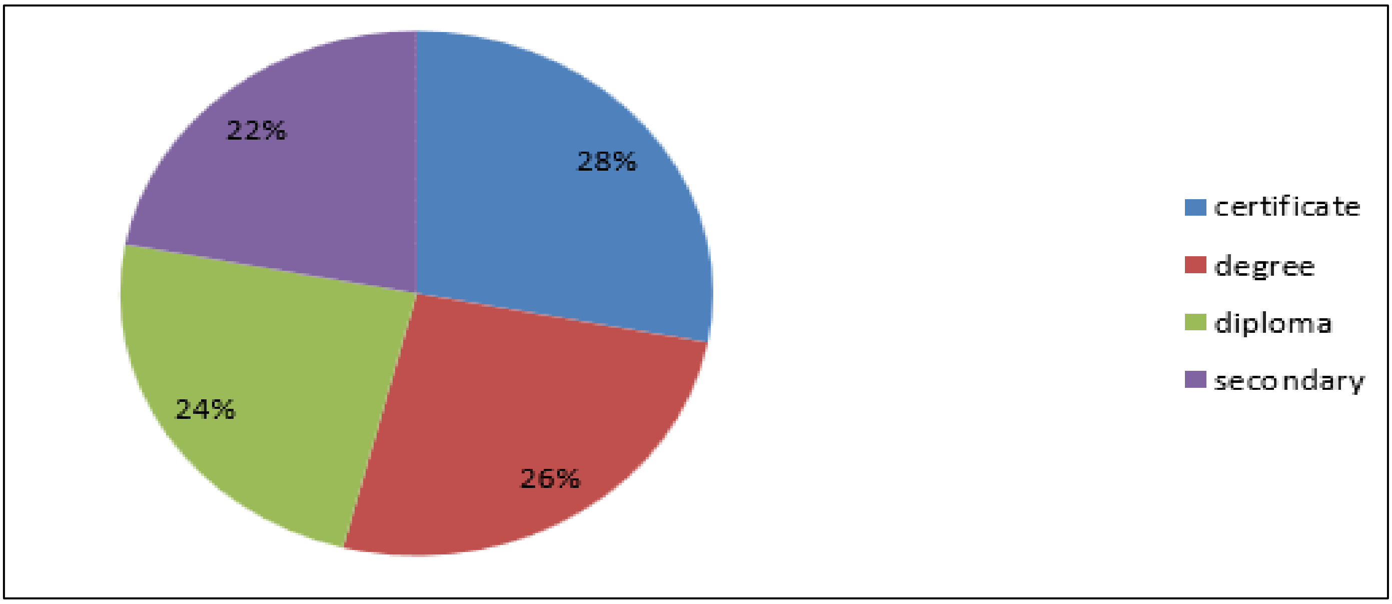


Fig 3 Education

The educational background of the respondents is relatively diverse, with a mix of different qualification levels. The most common qualification is a Certificate, held by 28% (14 individuals) of the respondents. This is closely followed by Degree holders, who make up 26% (13 individuals) of the sample. Diploma holders account for 24% (12 individuals), while those with Secondary education make up 22% (11 individuals) of the respondents. The distribution suggests that the sample has a slightly higher proportion of respondents with post-secondary qualifications (Certificate, Diploma, and Degree), which account for 78% of the total sample.

➤ *Current State of Green Technology Adoption in Residential Housing Construction Projects*

Table 2 of Future Rend

| | Freq. | Percent |
|---|---|---|
| Affordable off-grid solutions | 15 | 30.00 |
| Locally made eco-materials | 7 | 14.00 |
| Modular green housing designs | 18 | 36.00 |
| Smart home energy systems | 10 | 20.00 |
| Total | 50 | 100.00 |

The respondents' views on future trends reveal a strong interest in sustainable and innovative solutions. Modular green housing designs are the most popular trend, favored by 36% (18 individuals) of the respondents. Affordable off-grid solutions are also highly regarded, with 30% (15 individuals) of the sample selecting this option. Smart home energy systems are preferred by 20% (10 individuals), while locally made eco-materials are favored by 14% (7 individuals).

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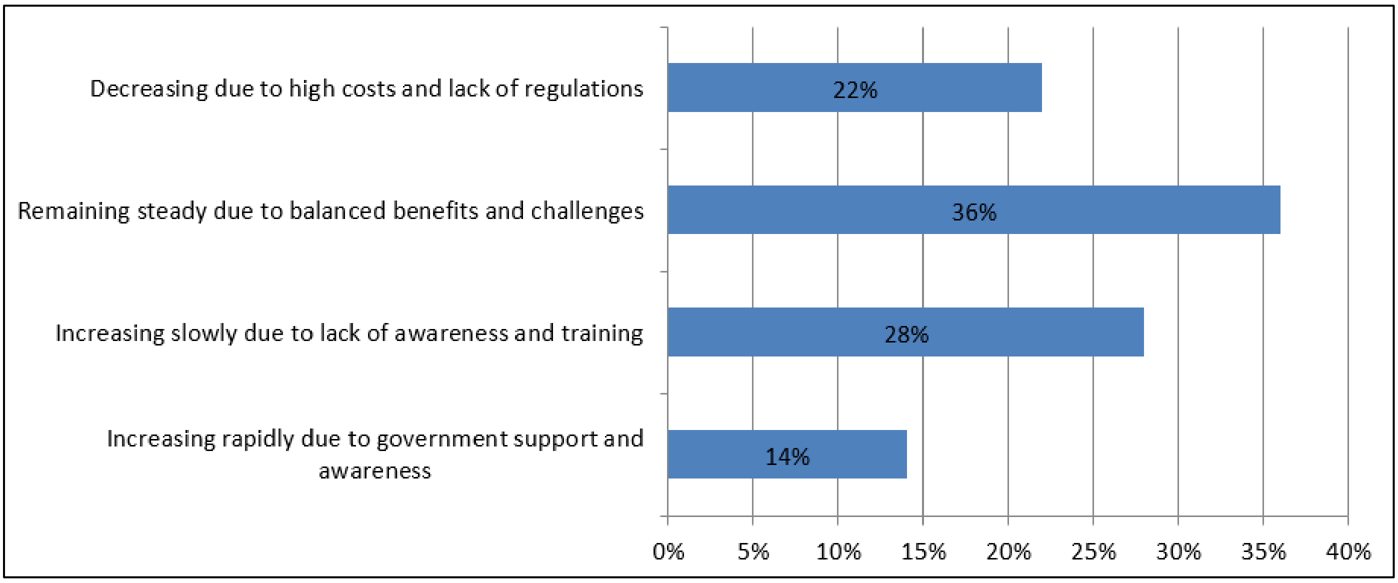


Fig 4 Current Trend

The respondents' perceptions of the current trend reveal a mixed outlook. The most common view is that the trend is remaining steady due to balanced benefits and challenges, selected by 36% (18 individuals) of the respondents. Another significant proportion, 28% (14 individuals), believe the trend is increasing slowly due to lack of awareness and training. Meanwhile, 22% (11 individuals) think the trend is decreasing due to high costs and lack of regulations, and 14% (7 individuals) believe it is increasing rapidly due to government support and awareness.

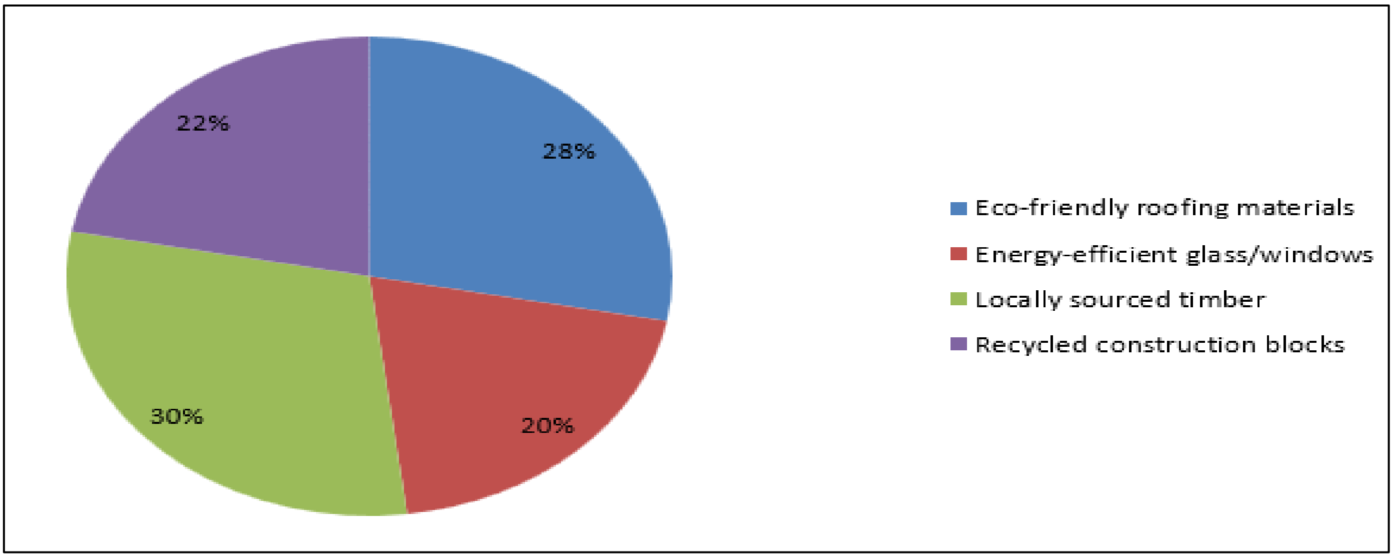


Fig 5 Material

The respondents' views on materials reveal a strong emphasis on sustainability and local resources. Locally sourced timber is the most preferred material, selected by 30% (15 individuals) of the respondents. Eco-friendly roofing materials are also highly preferred, chosen by 28% (14 individuals), while recycled construction blocks and energy-efficient glass/windows are recognized as important by 22% (11 individuals) and 20% (10 individuals) of the sample, respectively. The distribution suggests that respondents prioritize materials that are environmentally friendly, locally sourced, and sustainable.

Table 3 Digital Tool

| | Freq. | Percent |
|---|---|---|
| Building Information Modelling (BIM) | 14 | 28.00 |
| Mobile apps for energy monitoring | 17 | 34.00 |
| Online training platforms | 7 | 14.00 |
| Virtual reality design tools | 12 | 24.00 |
| Total | 50 | 100.00 |

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The respondents' preferences for digital tools reveal a strong interest in innovative technologies. Mobile apps for energy monitoring are the most popular choice, selected by 34% (17 individuals) of the respondents. Building Information Modelling (BIM) is also highly regarded, with 28% (14 individuals) of the sample choosing this option. Virtual reality design tools are favored by 24% (12 individuals), while online training platforms are selected by 14% (7 individuals).

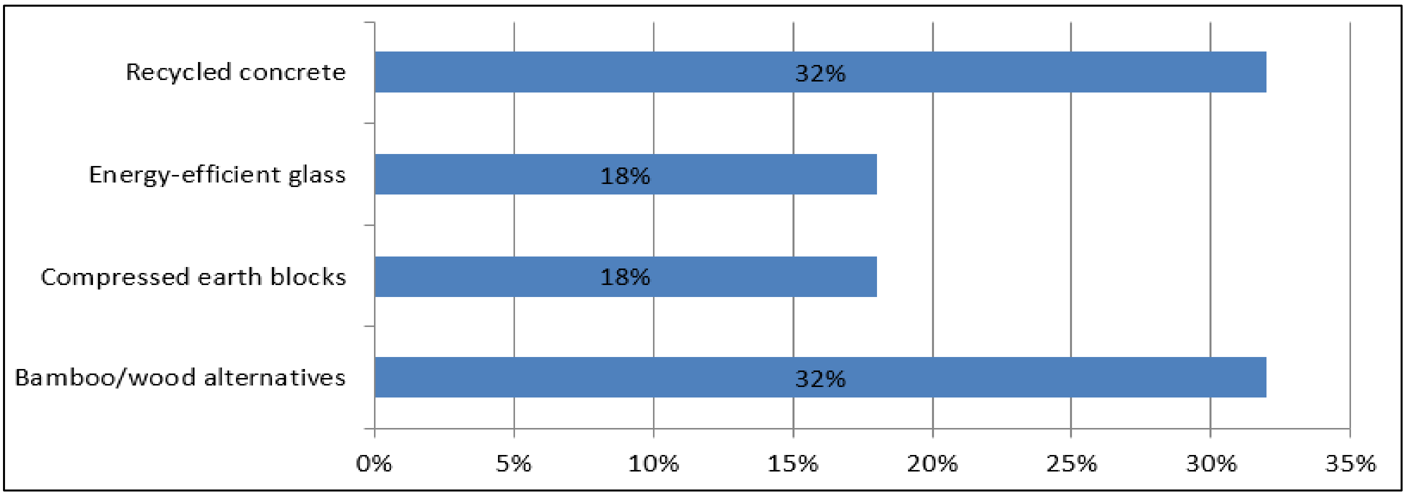


Fig 6 Eco Material

The respondents' preferences for eco-friendly materials are divided between sustainable natural materials and recycled options. Bamboo/wood alternatives and recycled concrete are the most popular choices, each selected by 32% (16 individuals) of the respondents. Compressed earth blocks and energy-efficient glass are also favored, with 18% (9 individuals) of the sample choosing each option.

➤ *Effects of Green Technology Implementation in Residential Housing Construction Projects*

Table 4 Valued Effect

| | Freq. | Percent |
|---|---|---|
| Environmental conservation | 8 | 16.00 |
| Financial savings | 9 | 18.00 |
| Health and comfort improvements | 16 | 32.00 |
| Prestige/status | 17 | 34.00 |
| Total | 50 | 100.00 |

The respondents' perceptions of the most valued effects reveal a notable emphasis on non-monetary benefits. Prestige/status is the most highly valued effect, selected by 34% (17 individuals) of the respondents, closely followed by health and comfort improvements, which are valued by 32% (16 individuals). Financial savings are also considered important, with 18% (9 individuals) of the sample choosing this option. Environmental conservation is valued by 16% (8 individuals) of the respondents.

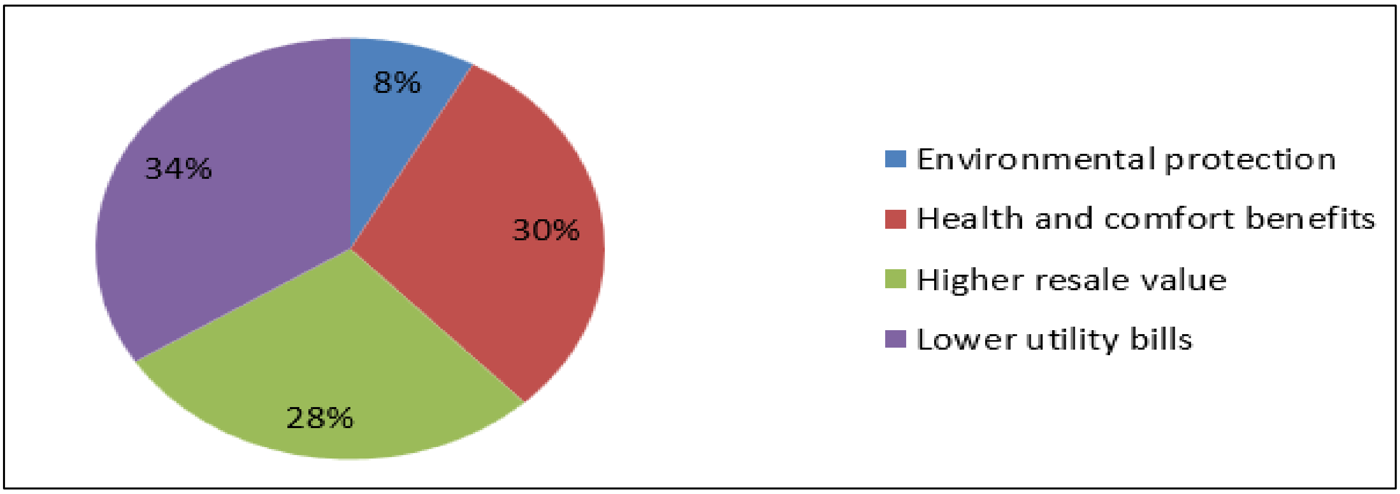


Fig 7 Motivation

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The respondents' motivations reveal a strong emphasis on practical benefits. Lower utility bills are the primary motivator, selected by 34% (17 individuals) of the respondents. Health and comfort benefits are also a significant motivator, chosen by 30% (15 individuals), while higher resale value is a motivator for 28% (14 individuals) of the sample. Environmental protection is the least motivating factor, selected by only 8% (4 individuals) of the respondents.

Table 5 Aware of

| | Freq. | Percent |
|---|---|---|
| Energy-efficient insulation and windows | 7 | 14.00 |
| Rainwater harvesting systems | 12 | 24.00 |
| Solar energy systems | 21 | 42.00 |
| Waste recycling system | 10 | 20.00 |
| Total | 50 | 100.00 |

The respondents' awareness of sustainable practices reveals a strong familiarity with solar energy systems, selected by 42% (21 individuals) of the sample. Rainwater harvesting systems are also well-known, with 24% (12 individuals) of respondents aware of this practice. Waste recycling systems are recognized by 20% (10 individuals), while energy-efficient insulation and windows are known by 14% (7 individuals) of the respondents.

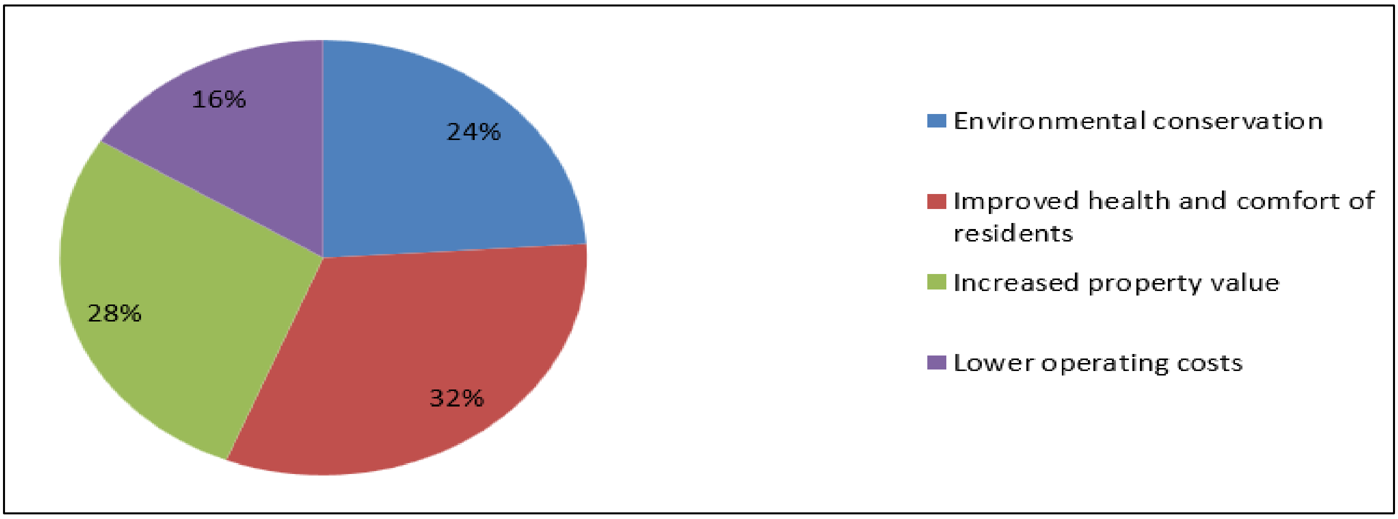


Fig 8 Long Term Benefit

The respondents' perceptions of long-term benefits reveal a strong emphasis on occupant well-being and property value. Improved health and comfort of residents is considered the most significant long-term benefit, selected by 32% (16 individuals) of the respondents. Increased property value is also highly valued, chosen by 28% (14 individuals), while environmental conservation is recognized as a long-term benefit by 24% (12 individuals) of the sample. Lower operating costs are seen as a long-term benefit by 16% (8 individuals) of the respondents.

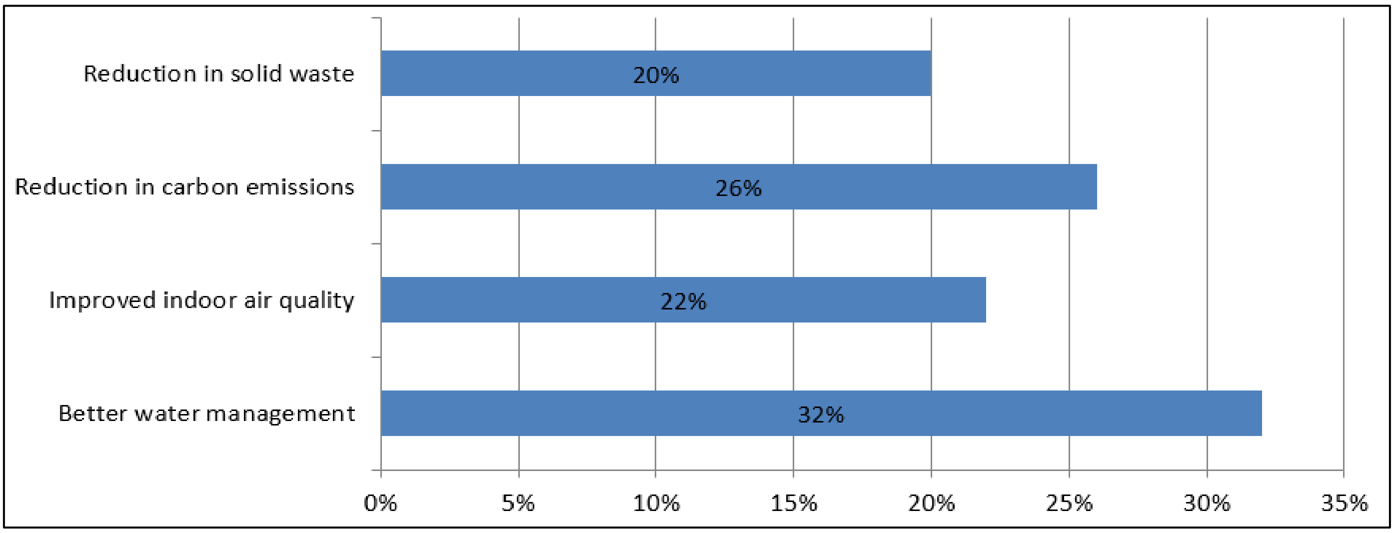


Fig 9 Environmental Effect

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The respondents' views on environmental effects reveal a strong emphasis on resource management and emissions reduction. Better water management is considered the most significant environmental effect, selected by 32% (16 individuals) of the respondents. Reduction in carbon emissions is also highly valued, chosen by 26% (13 individuals), while improved indoor air quality is recognized as an important effect by 22% (11 individuals) of the sample. Reduction in solid waste is seen as an environmental effect by 20% (10 individuals) of the respondents. The distribution suggests that respondents prioritize environmental benefits related to resource conservation and climate change mitigation.

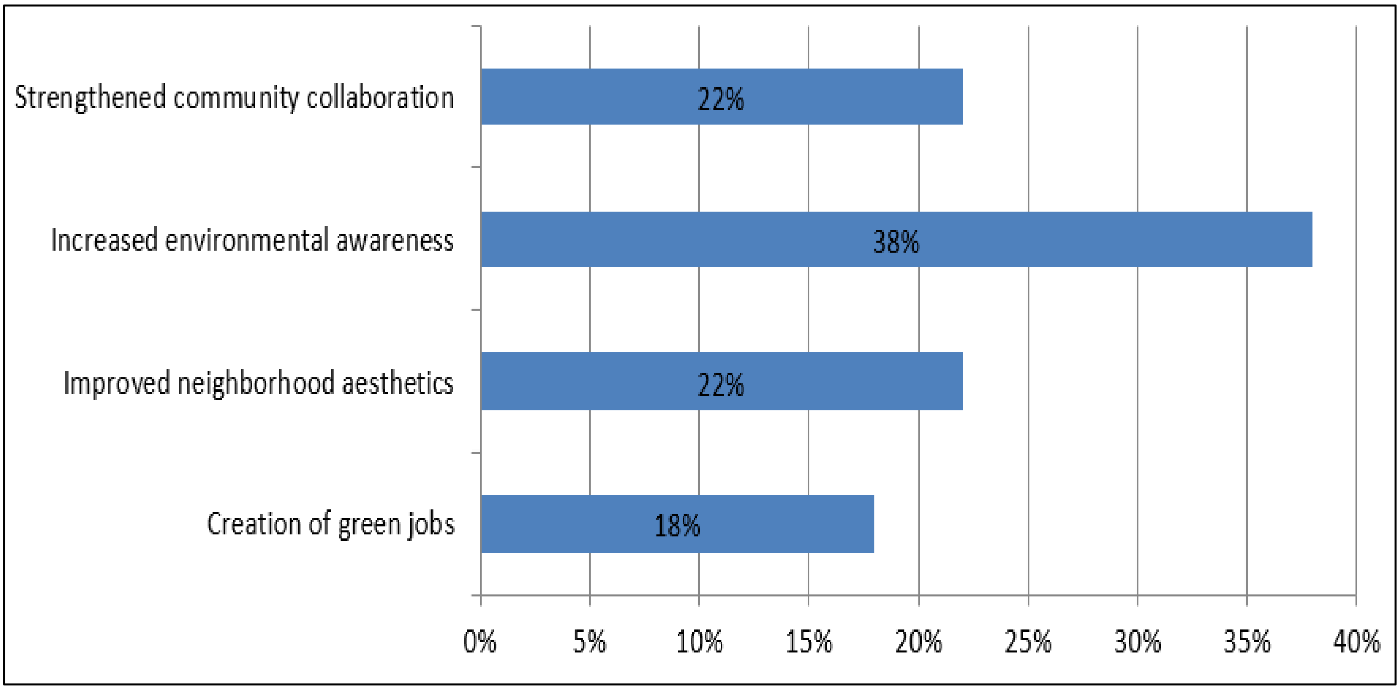


Fig 10 Community Effect

The respondents' views on community effects reveal a strong emphasis on environmental awareness and community cohesion. Increased environmental awareness is considered the most significant community effect, selected by 38% (19 individuals) of the respondents. Improved neighborhood aesthetics and strengthened community collaboration are also highly valued, each chosen by 22% (11 individuals) of the sample. Creation of green jobs is recognized as a community effect by 18% (9 individuals) of the respondents. The distribution suggests that respondents prioritize community benefits related to environmental consciousness and social bonding.

- *Challenges to Green Technology Adoption in Residential Housing Construction*

Table 6 Primary Challenge

| | Freq. | Percent |
|---|---|---|
| High initial investment cost | 7 | 14.00 |
| Lack of technical expertise | 7 | 14.00 |
| Limited availability of green materials | 11 | 22.00 |
| Low client demand | 7 | 14.00 |
| Regulatory or approval delays | 5 | 10.00 |
| Uncertainty about performance | 13 | 26.00 |
| Total | 50 | 100.00 |

The respondents' views on primary challenges reveal concerns about effectiveness and resource availability. Uncertainty about performance is considered the most significant challenge, selected by 26% (13 individuals) of the respondents. Limited availability of green materials is also a major challenge, chosen by 22% (11 individuals), while high initial investment cost, lack of technical expertise, and low client demand are each recognized as challenges by 14% (7 individuals) of the sample. Regulatory or approval delays are seen as a challenge by 10% (5 individuals) of the respondents. The distribution suggests that respondents prioritize concerns related to performance reliability and resource constraints.

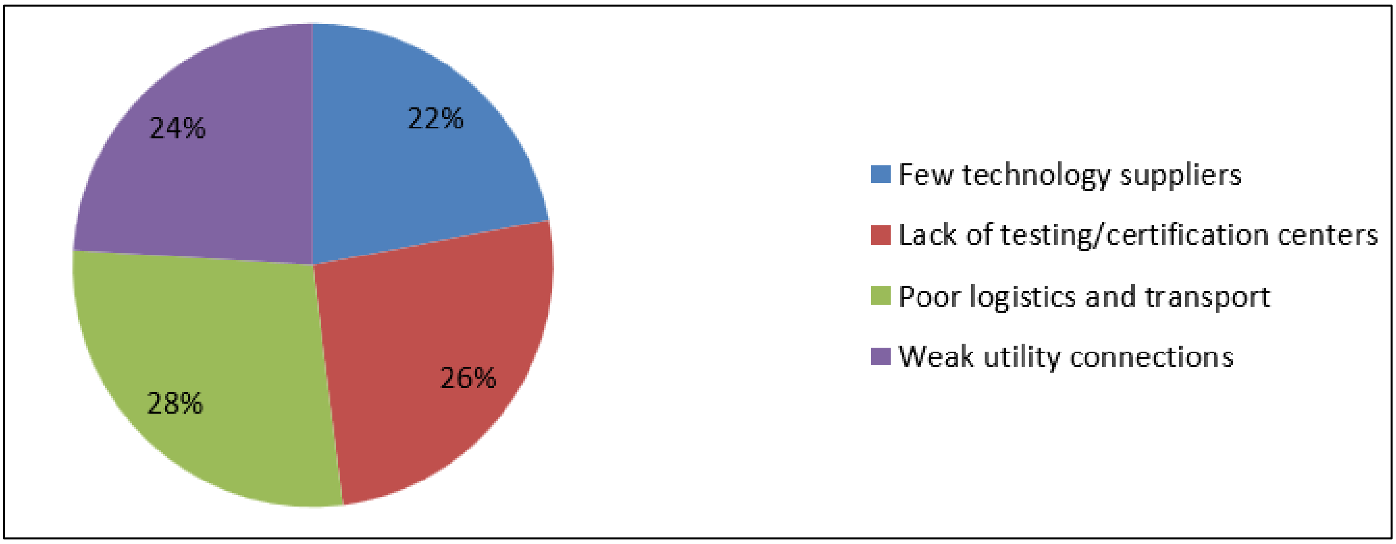


Fig 11 Infrastructure Gap

The respondents' views on infrastructure gaps reveal concerns about foundational support systems. Poor logistics and transport are considered the most significant gap, selected by 28% (14 individuals) of the respondents. Lack of testing/certification centers is also a major gap, chosen by 26% (13 individuals), while weak utility connections are recognized as a gap by 24% (12 individuals) of the sample. Few technology suppliers are seen as a gap by 22% (11 individuals) of the respondents. The distribution suggests that respondents prioritize infrastructure needs related to physical and institutional support, highlighting the importance of logistics, testing, and utility infrastructure.

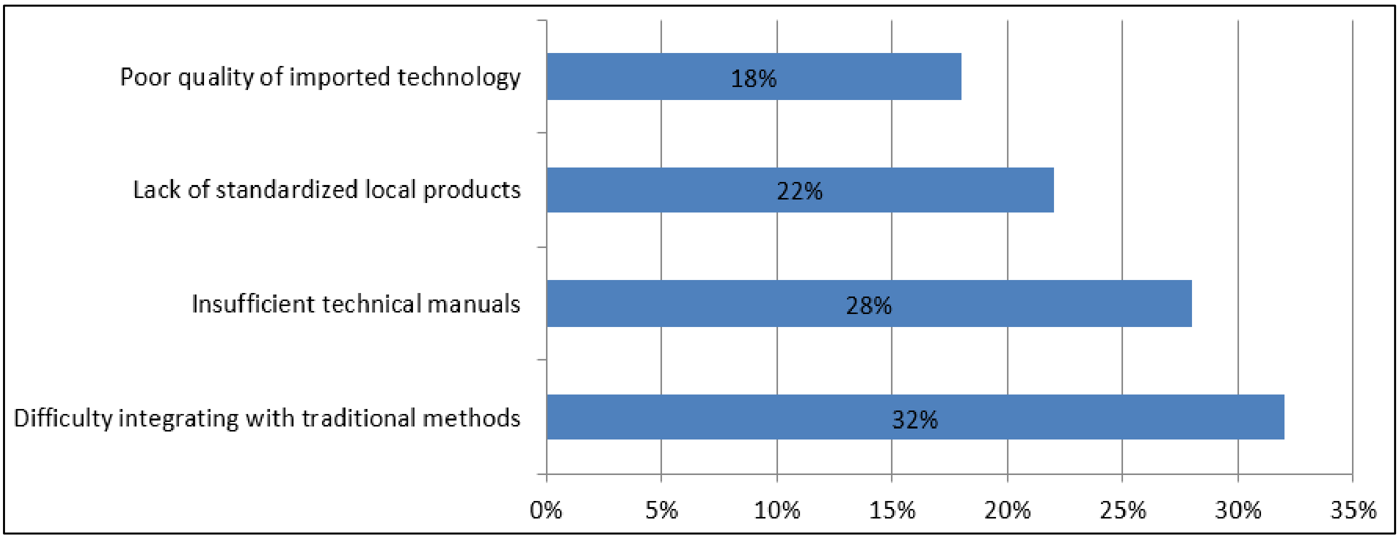


Fig 12 Observed Challenge

The respondents' views on observed challenges reveal difficulties in integration and standardization. Difficulty integrating with traditional methods is considered the most significant challenge, selected by 32% (16 individuals) of the respondents. Insufficient technical manuals are also a major challenge, chosen by 28% (14 individuals), while lack of standardized local products is recognized as a challenge by 22% (11 individuals) of the sample. Poor quality of imported technology is seen as a challenge by 18% (9 individuals) of the respondents. The distribution suggests that respondents face practical challenges in adapting new technologies to existing systems and processes.

Table 7_Regulatory Gap

| | **Freq.** | **Percent** |
|---|---|---|
| Absence of certification systems | 11 | 22.00 |
| Delayed policy implementation | 16 | 32.00 |
| Lack of coordination between ministries | 8 | 16.00 |
| Weak enforcement of laws | 15 | 30.00 |
| Total | 50 | 100.00 |

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The respondents' views on regulatory gaps reveal concerns about policy implementation and enforcement. Delayed policy implementation is considered the most significant gap, selected by 32% (16 individuals) of the respondents. Weak enforcement of laws is also a major gap, chosen by 30% (15 individuals), while absence of certification systems is recognized as a gap by 22% (11 individuals) of the sample. Lack of coordination between ministries is seen as a gap by 16% (8 individuals) of the respondents. The distribution suggests that respondents prioritize challenges related to effective policy execution and regulatory oversight.

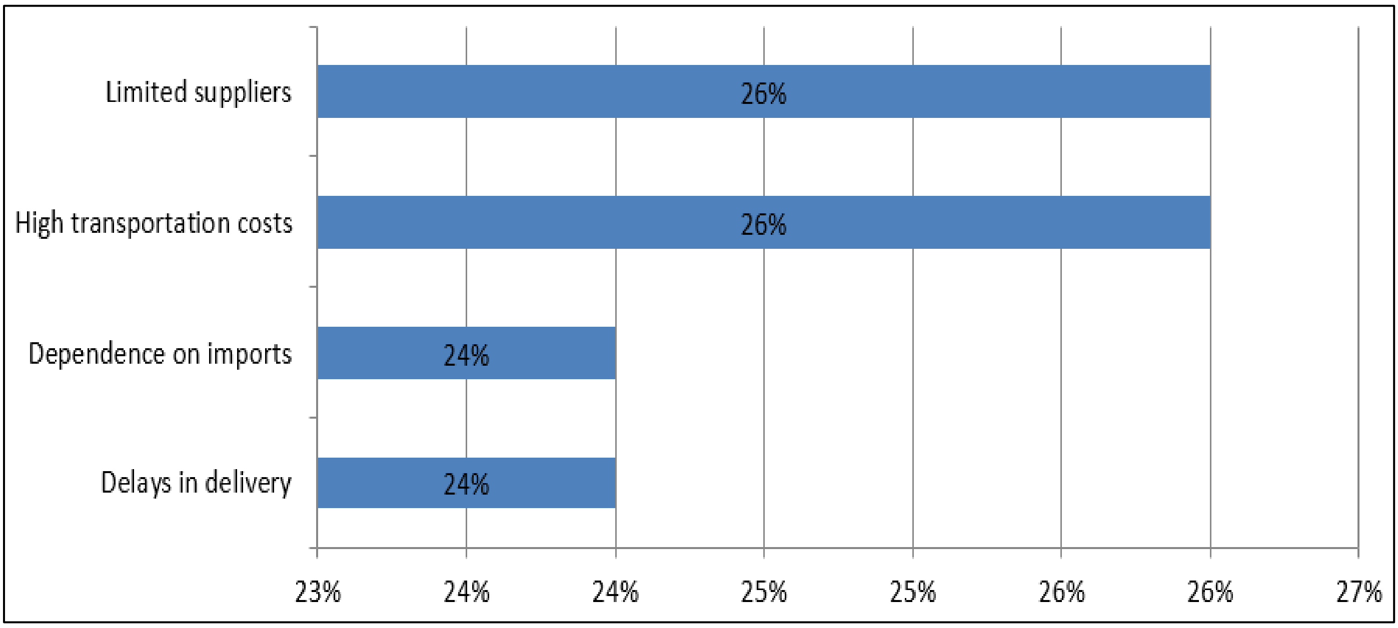


Fig 13 Supply Chain Issue

The respondents' views on supply chain issues reveal concerns about logistics and supplier availability. High transportation costs and limited suppliers are considered the most significant issues, each selected by 26% (13 individuals) of the respondents. Delays in delivery and dependence on imports are also major concerns, each chosen by 24% (12 individuals) of the sample. The distribution suggests that respondents face challenges related to supply chain efficiency, reliability, and resilience, particularly in terms of transportation costs and supplier availability.

➢ *Discussion of the Findings*

- *Current State of Green Technology Adoption in Residential Housing Construction Projects.*

The findings reveal a strong preference for sustainable and innovative housing solutions, particularly modular green housing (36%) and off-grid systems (30%), emphasizing efficiency, adaptability, and cost-effectiveness (Smith, 2019; Kibert, 2016). However, adoption remains constrained by financial, regulatory, and capacity challenges (Yuan et al., 2011; Darko et al., 2017). Environmental sustainability emerged as the key driver (40%), supported by market demand (22%) and cost efficiency (20%) (Wong et al., 2017; Oti&Kinuthia, 2018). Respondents also favored locally sourced and recycled materials, reinforcing alignment with global sustainable practices (Zuo& Zhao, 2014; Ding, 2008). Digital tools such as BIM and energy-monitoring apps were highlighted as essential for efficiency and innovation (Azhar, 2011; Eastman et al., 2011). Overall, the study shows that green technology adoption in Kitwe's housing sector is environmentally motivated but limited by weak policy support, high costs, and low awareness. Addressing these constraints requires integrated strategies combining policy incentives, capacity building, and technological innovation to achieve sustainable construction outcomes. These findings support global evidence that sustainable construction depends on the synergy of environmental, economic, and digital factors driving adoption (Häkkinen&Belloni, 2011; Oti&Kinuthia, 2018).

- *Effects of Green Technology Implementation in Residential Housing Construction Projects*

The findings indicate that homeowners' adoption of green technologies in residential construction is driven more by social prestige, health, and comfort than by purely economic or environmental concerns. This supports Darko et al. (2017) and Kibert (2016), who found that non-monetary benefits strongly influence sustainable housing adoption. Awareness was highest for solar energy systems (Asumadu-Sarkodie&Owusu, 2016), revealing limited knowledge of other green practices. Consistent with Olubunmi et al. (2020), financial savings and improved living conditions remain practical motivators. Respondents also recognized long-term gains, including property value appreciation and enhanced well-being (Zuo& Zhao, 2014; Ding, 2008). Additionally, environmental benefits such as improved water management and reduced emissions (Kibert, 2016; UNEP, 2020) were acknowledged, though secondary to personal and social factors. Community-related impacts—like increased environmental awareness, improved neighborhood aesthetics, and green job creation—reflect sustainability's social dimension (World Bank, 2019; Zuo& Zhao, 2014). These results suggest that green housing policies should emphasize both individual and communal benefits while expanding awareness of diverse sustainable practices. Overall, the study affirms that green technology adoption is shaped by an interplay of economic practicality, social prestige, environmental consciousness, and community well-being.

- *Challenges to Green Technology Adoption in Residential Housing Construction*

The findings reveal that the adoption of green technologies in residential housing construction faces significant regulatory, technological, and infrastructural challenges. Respondents identified performance uncertainty (26%) and scarcity of green materials (22%) as the leading barriers, consistent with Zulu (2022) and Aghimien et al. (2018), who emphasized inadequate performance data and material shortages as deterrents to adoption. High costs, limited expertise, and weak regulatory frameworks further constrain implementation. Technological barriers such as unreliable suppliers (Agyekum et al., 2020), poor quality control (Zhang & Chen, 2019), and skill shortages (Ofori, 2017) were also highlighted. Integration challenges between new and traditional methods (Gibb &Isack, 2003) and lack of technical documentation (Love et al., 2019) indicate low standardization, complicating technology transfer. Regulatory gaps—including delayed implementation and weak enforcement—reflect poor policy execution (Karamoozian, 2025; Ayarkwa et al., 2022). Infrastructural weaknesses such as poor logistics, lack of testing facilities, and dependence on imports (Hwang & Tan, 2021) further hinder progress. These findings align with Ding (2008) and Zuo and Zhao (2014), who argue that sustainable construction requires robust infrastructure, skilled labor, and coherent policy frameworks. Addressing these systemic barriers demands integrated interventions—policy reform, supply chain strengthening, technical training, and localized production—to enable effective, large-scale adoption of green housing technologies.

## V. CONCLUSION

Based on the findings, the current state of green technology adoption in residential housing construction projects reflects both growing interest and notable challenges. Respondents showed a strong preference for modular green housing designs (36%) and affordable off-grid solutions (30%), which together account for 66% of future adoption trends. However, when assessing the present state, 36% viewed the trend as stable, while 28% saw it as slowly increasing due to limited awareness and training. Environmental concerns (40%) remain the strongest driver of adoption, supported by market demand (22%) and cost savings (20%). Material preferences are dominated by locally sourced timber (30%) and eco-friendly roofing materials (28%), with mobile apps for energy monitoring (34%) and BIM (28%) emerging as key digital tools. The effects of adoption are largely tied to prestige (34%) and health/comfort improvements (32%), with financial savings (18%) and environmental conservation (16%) considered secondary. While awareness of practices like solar energy (42%) and rainwater harvesting (24%) is high, adoption is hindered by uncertainties about performance (26%), limited material availability (22%), and high upfront costs (14%). Infrastructure gaps such as poor logistics (28%) and lack of certification centers (26%), along with regulatory delays (32%) and weak enforcement (30%), further slow progress. Overall, the statistics suggest that while awareness, interest, and environmental motivation for green technology adoption are strong, practical challenges—ranging from supply chain inefficiencies to policy enforcement—remain significant barriers. This indicates that wider adoption will require coordinated policy support, investment in infrastructure, and strengthened technical capacity.

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