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Integrating Green Building Practices in Constraction Project Management: A Case Study of Kafue Hook Bridge Project, Central Province of Zambia

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Abstract: This study analyzed the adoption and effectiveness of green building practices in the Kafue Hook Bridge project in Zambia, focusing on challenges and opportunities associated with sustainable construction in a developing country context. The objectives were to identify go green building practices employed in construction of projects, evaluate their effectiveness, access the factors influencing the green building practices success and explore implementation limitations. Using a case study design, data was collected from various specialists like The Environmental specialists, Engineers, Procurement personels and Architects, targeting individuals aged 25 to 65. A sample of 50 respondents was determined through purposive sampling methods due to limited resources and data was analyzed using SPSS. The study was grounded on the Ecological Modernization Theory (EMT). The results highlighted that 94% of specialists were knowledgeable about green building practices, and 88% agreed that the project achieved its objectives, leading to positive outcomes. Nevertheless, challenges such as high upfront costs of green materials 36%, technological limitations 28%, resource constraints 98%, and inadequate stakeholder collaboration 76% negatively affected implementation. In spite of these barriers, the study indicated significant alignment with sustainability objectives, indicating the success of green practices in contributing to the project's overall effectiveness. Stakeholder collaboration and regulatory frameworks were identified as critical for overcoming challenges, with 76% of respondents emphasizing the need for partnerships. The study recommended increased investment in research, development of cost-effective green materials, innovative technologies, clearer policies, and climate-resilient designs for future projects. Stakeholders are encouraged to adopt these recommendations to enhance the scalability and sustainability of green practices in Zambia's construction sector. This research has given a valuable insights about the importance of green building practices in infrastructure projects, giving practical recommendations to address challenges and improve outcomes. It underscores the importance of continuous investment in innovation, policy clarity, and stakeholder engagement to foster sustainable construction in Zambia and other developing countries.

Keywords: *Ecological Modernization Theory, Project Management, Green Building Practices, Sustainable Development.*

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I. INTRODUCTION

The construction sector has got significant negative effect on environment through resource depletion, energy consumption, and pollution (Ding, 2018). As global awareness of environmental issues increases, green construction practices have emerged as an important factor in reducing the environmental effect of construction (Häkkinen & Belloni, 2011). These practices aim to support environmental sustainability and economic efficiency by increasing energy efficiency, reducing waste, and using sustainable materials (Kiebert, 2016).

Green building practices are gaining popularity around the world, driven by regulatory frameworks, market demand, and environmental awareness. Standards such as Leadership in Energy and Environmental Design (LEED) in the United States and Building Research Deployment Environmental

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Assessment Method (BREEAM) in the United Kingdom have established guidelines for sustainable construction and have helped promote widespread adoption of green principles (Reed et al., 2019). These standards promote water conservation, energy efficiency, and the use of sustainable materials, leading to buildings that provide environmental and economic benefits (Darko et al., 2017).

Despite the rapid expansion of Zambia's construction sector due to infrastructure projects to boost economic growth, the country faces unique barriers to adopting green building practices, including limited financial resources, insufficient technical expertise and weak regulatory frameworks and these challenges remain (Mwasha, Williams & Iwaro, 2017). Traditional practices in the sector contribute to deforestation, soil erosion and increased greenhouse gas emissions, with construction activities accounting for approximately 23% of Zambia's national emissions (ZEMA, 2020).

Zambia's Vision 2030 is also in line with ZEMA, which outlines the country's long-term development goals through its Seventh National Development Plan, 7NDP, focusing on sustainable development and environmental management (Zambia Ministry of National Development Planning, 2017). These policies are consistent with international commitments like the United Nations Sustainable Development Goals (SDGs), particularly Goal 11 (UN, 2015). This study analyzed the Kafue Hook Bridge project and provided valuable insights into the adoption and implementation of go green building principles in Zambia.

➢ *Statement of the Problem*

Despite significant advances in green building practices globally, adoption has been limited in Zambia due to financial constraints, lack of technical expertise, and lack of a strong regulatory framework (Hwang & Tan, 2012; Zuo & Zhao, 2014). The Zambia Green Building Association (ZGBA) reported that only 5% of construction projects in the country adopt sustainable practices, which increases operating costs and has a negative effect on the environment (ZGBA, 2018). Recent statistics show that the construction sector in Zambia accounts for approximately 23% of country's greenhouse gas emissions, further adding to climate change and environmental degradation (Zambia Environmental Management Agency, 2020).

This case highlighted the need for research to assess green practices, their effectiveness, factors influencing implementation strategies and key constraints to implementing green building practices in the Zambian context.

➢ *General Objective*

To assess the integration of green building practices in construction project management: A case study of a Kafue Hook Bridge project, Central Province of Zambia.

➢ *Specific Objectives*

- To establish the go green building practices applied in the Kafue Hook Bridge project.
- To determine the effectiveness of green building practices in the Kafue Hook Bridge project.
- To assess the underlying factors influencing green building practice success in construction projects
- To determine the limits in implementation of go green building principles in construction projects.

➢ *Research Questions*

- What are the go green building practices applied in the Kafue Hook Bridge project?
- What is the effectiveness of green building practices in the Kafue Hook Bridge project?
- What are the underlying factors influencing green building practice success in construction project?
- What are the limits in the implementation of green building practices in construction project?

➢ *Significance of the Study*

The construction sector is a main cause of environmental degradation, including carbon emissions, energy consumption, and resource depletion (Ritchie and Roser, 2020). Green building practices have been shown to be important for sustainable development, reduced environmental impact, increased resource efficiency, and long-term cost savings (Kiebert, 2016). This study introduces green building practices and analyses their effectiveness, focusing on the Kafue Hook Bridge, a major infrastructure project in Zambia (Turner, 2021). The findings are intended to provide insights into sustainable construction in line with Zambia's Vision 2030 and the Seventh National Development Plan (Zambia Ministry of National Development Planning, 2017). By addressing issues and providing practical recommendations, the research contributes to environmental management and the adoption of green practices across the country.

By examining green construction practices used in projects, this study provides valuable insight into how to integrate sustainable environmental impacts, improve resource efficiency, and reduce long-term costs (Kiebert, 2016). It also presents new findings and insights into the implementation and benefits of green construction principles, taking Kafue Hook Bridge as a case study.

This study is timely and in line with Zambia's increasing emphasis on sustainable infrastructure, as outlined in Vision 2030 and the Seventh National Development Plan (7NDP) (Ministry of National Development Planning, Zambia, 2017, 2021). The research will further provide effective recommendations to policymakers, project managers and engineers and support the implementation of green building practices across the country. By addressing sustainability issues, the research contributes to improving environmental governance and advancing Zambia's development agenda.

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➢ *Theoretical Framework*

This study is based on the ecological modernization theory (EMT). This theory emphasizes that economic growth and environmental sustainability can coexist through innovation, policy change, and organizational change (Moll and Sonnenfeld, 2020). It also explains how to integrate green practices into traditional projects, emphasizing the role of technology, collaboration, and institutional change in achieving sustainable outcomes.

For the Kafue Hook Bridge project, EMT provides a framework for analysing how green construction practices, such as green materials and energy-efficient design, meet development and environmental objectives. Project managers are tasked with adhering to environmental policies, engaging stakeholders, and adopting green technologies to reduce environmental damage. By implementing sustainable practices, projects can reduce costs, increase environmental benefits, and achieve long-term economic efficiencies. EMT emphasizes the importance of collective action, compliance, and innovation in promoting sustainable infrastructure development and innovation.

II. LITERATURE REVIEW

The green construction practices of the Kafue Hook Bridge project emphasize sustainability through resource efficiency, waste reduction, and energy optimization to ensure environmental responsibility throughout the infrastructure's life cycle (Wang et al., 2020).

Globally, these principles, such as use of recycled materials as well as energy-efficient design, contribute to addressing climate change and sustainable development goals, especially in countries which are still developing like Zambia (Clement, 2020; Mol, 2022). Certifications such as LEED and BREEAM standardize these practices, improve environmental performance, and reduce operating costs (Kats, 2003). Innovative approaches such as solar lighting and green materials have been successfully used in bridges around the world, setting benchmarks for sustainability (Jones and Matthews, 2021). The integration of green practices in Zambia reflects growing political support and regional efforts to balance environmental and economic needs in large-scale infrastructure projects (Smith, 2021).

The literature review highlights the effectiveness of green construction practices in bridge construction, focusing on the Kafue Hook Bridge. Green certifications, such as LEED and BREEAM, provide a framework for sustainability, with a focus on resource efficiency, carbon reduction, and waste management (US Green Building Council, 2020; BREEAM, 2021). Sustainable materials, such as recycled aggregates and low-carbon concrete, reduce environmental impact, and energy-efficient systems, such as solar panels, reduce operating costs (Mehta & Meryman, 2019; Wang et al., 2022). Water conservation practices, including rainwater reuse, can reduce environmental impacts around sensitive ecosystems (Van der Zwaan et al., 2019). Performance indicators include carbon emission reductions, cost savings, and lessons learned from successful green bridge projects such as the Lowry Avenue Bridge and the Pearl River Bridge (Fowler & Rauch, 2019; Fernandes et al., 2020). These practices improve sustainability, efficiency and long-term sustainability and provide a benchmark for infrastructure projects in Zambia.

The literature highlights several factors leading to success of green building principles in construction, highlighting policy frameworks, costs, stakeholder perceptions and technological barriers. While developed countries benefit from strong policies and incentives that encourage green practices (Wang et al., 2020), Zambia suffers from weak implementation and limited financial resources (Mubita, 2022). The Kafue Hook Bridge project focuses on balancing infrastructure requirements and environmental protection through the use of sustainable materials and renewable energy, despite challenges such as high costs and reliance on imported technologies (ZEMA, 2023). Lessons from global and regional case studies highlight the need for localized strategies and stakeholder engagement (Chileshe & Kikwasi, 2021; UNEP, 2020).

Green building practices (GBP) are recognized globally for their environmental and financial benefits, but there is still a little local research in Zambia, especially for infrastructure projects such as the Kafue Hook Bridge. Although the global literature emphasizes energy efficiency, stakeholder collaboration, and advanced technologies (Akadiri & Olomolaiye, 2021; Kibert, 2020), there are still challenges in addressing Zambia's unique challenges, including financial constraints, weak policy enforcement, and local environmental requirements, and further research is required to evaluate the effectiveness, implementation, as well as long-term benefits of GBP in Zambia's socioeconomic and environmental context (Chileshe & Kikwasi, 2021; ZEMA, 2023).

➢ *Gaps in the Literature*

While global research has highlighted the benefits of GBP, its application in resource-poor environments in Zambia remains under-researched. Projects such as the Kafue Hook Bridge (UNEP, 2020; ZEMA, 2023) require regional studies to address the challenges of balancing infrastructure development and biodiversity conservation. Existing research has not adequately examined how stakeholder dynamics, including community participation, influence the adoption of GBP in Zambia. This gap is especially evident in projects involving multiple stakeholders, such as the Kafue Hook Bridge (Shafii et al., 2021). Long-term benefits: Studies focus on immediate benefits, such as cost savings, but ignore long-term impacts, such as reduced maintenance costs and ecosystem conservation in large-scale infrastructure projects in Zambia (Dwaikat & Ali, 2018). Additionally, green building literature often emphasizes strategies like regulatory compliance, stakeholder engagement, and the use of green certification systems (Kibert, 2020). However, the gap lies in documenting how these implementation strategies have been adapted or modified in African construction projects, particularly in Zambia. There is limited literature exploring how local governance structures, financial constraints, and

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technical expertise influence the implementation of green practices.

➢ *Critique of the Literature*

Relying on Western performance measures, it ignores the socio-economic realities of Zambia and limits the relevance of the research to local projects (Mokhlesian & Holmén, 2021). Much of the literature in Zambia is theoretical and there is no much empirical data available to assess the implementation of GBP in specific contexts, such as the Kafue Hook Bridge (ZEMA, 2023). The literature prioritizes regulatory frameworks without addressing the real implementation issues in Zambia, where enforcement mechanisms and resources are limited (Wang et al., 2020; ZEMA, 2023). Further, much of the literature assumes a one-size-fits-all approach, without adequately accounting for regional climate and resource availability. Additionally, most literature fails to explore the socio-political issues hindering implementation of these practices, especially in public infrastructure projects (Darko et al., 2017). This undermines the ability to fully understand the complexity of executing green initiatives in the Kafue Hook Bridge project.

III. RESEARCH METHODOLOGY

A case study method was used to explore experiences in real situations. The target population consisted of various specialist and these include the environmental specialists, engineers, procurement personals and architects, with diverse demographic views. A sample of 50 respondents was selected through purposive sampling methods to allow for robust quantitative analysis. This number of respondents was selected due to limited resources. Data was collected through surveys and document analysis, which allowed for methodological and data triangulation to validate study findings. Limitations include generalizability, limited resources, and problems with evolving environmental standards. Ethical considerations such as informed consent, confidentiality, and compliance with ethical standards were prioritized to ensure responsible research practices.

IV. RESEARCH FINDINGS AND DISCUSSIONS

➢ *Presentation of Findings Based on the Demographic Information of Respondents*

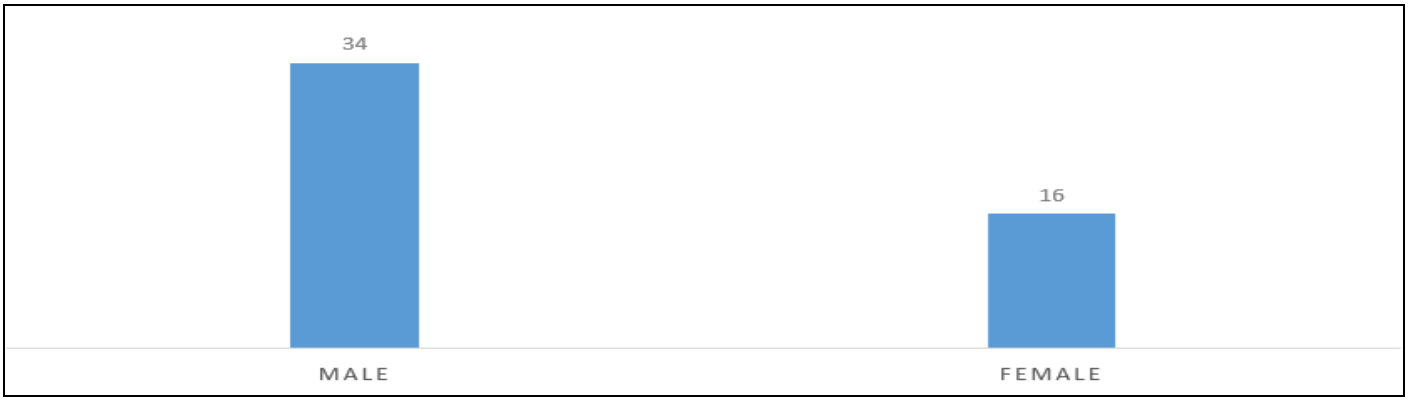

Fig 1 Gender of Respondents.

The gender representation of male respondents (34), constitute the majority of respondents. Female Respondents (16), while lower, is still significant and highlights the inclusion of women in roles relevant to project management and environmental sustainability.

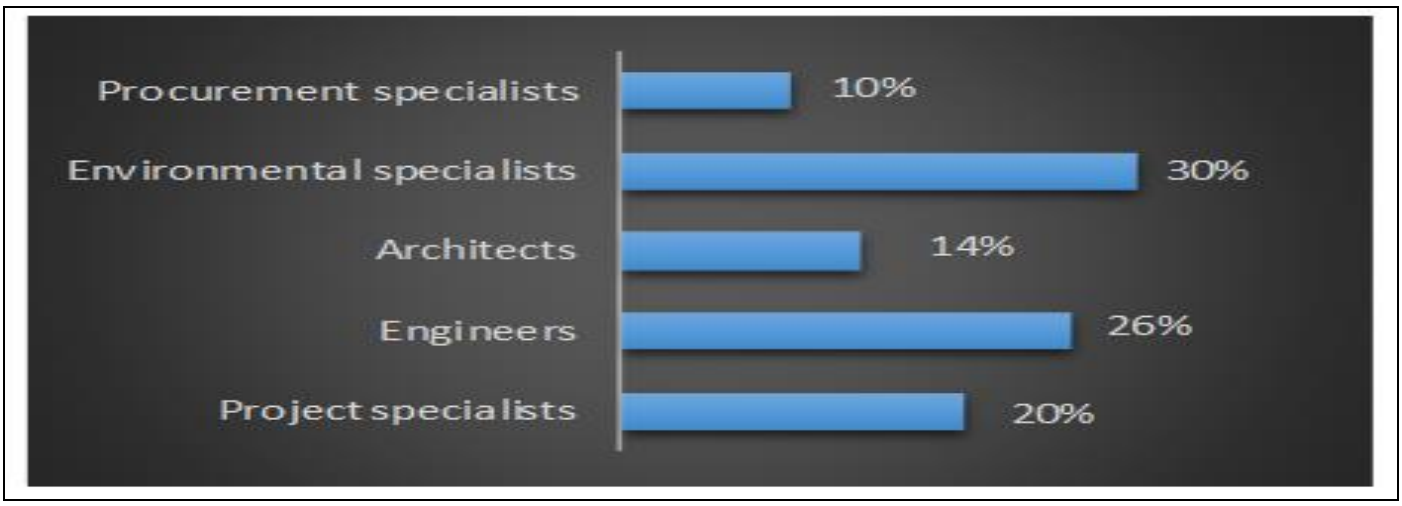

Fig 2 Speciality of Respondents.

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Figure 02 indicates majority representation of environmental specialist 30% and engineers 26%. Project specialists 20%, while architects 14% and procurement specialist 10%. This distribution ensures a holistic analysis of the specific objectives, particularly the evaluation of green practices, their effectiveness, influencing factors, and challenges.

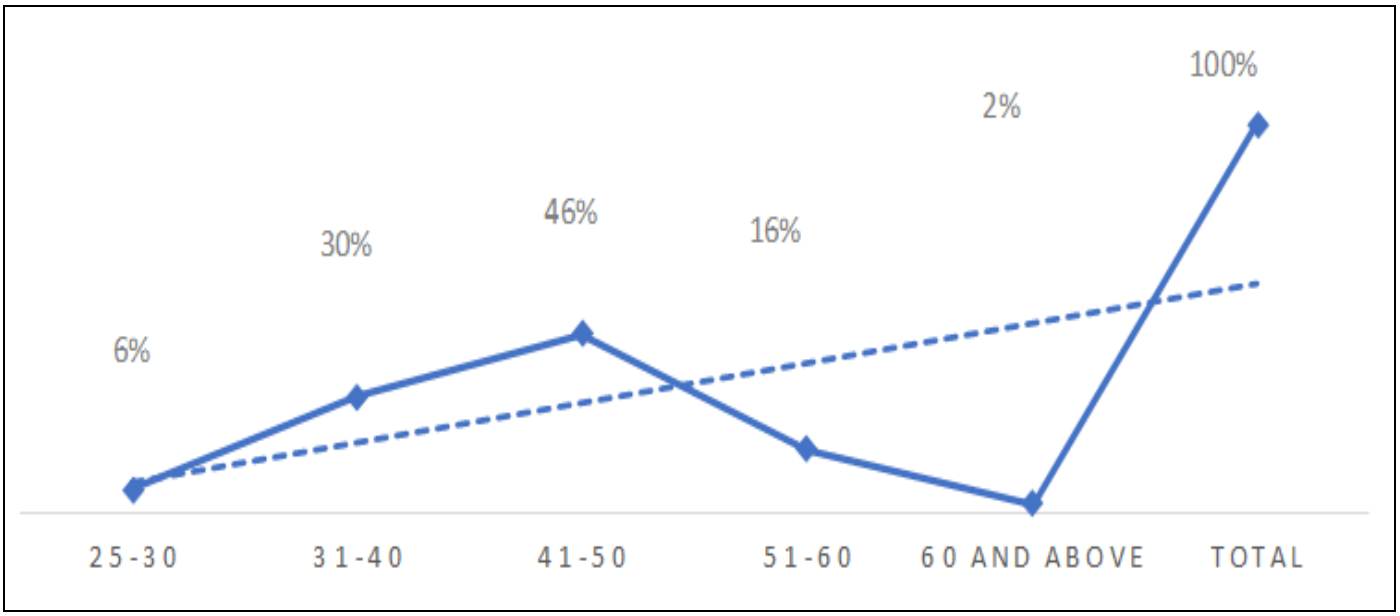

Fig 3 Age Group of Respondents.

Findings show that among respondents, 41–50 years accounts for (46%), 31–40 years (30%), Senior professionals are in the age group of 51–60 years (16%), 25–30 years (6%) while 60 and above accounting for (2%) representing the smallest group highly senior professionals, advisors, or retirees who are engaged in the project at a consultative level.

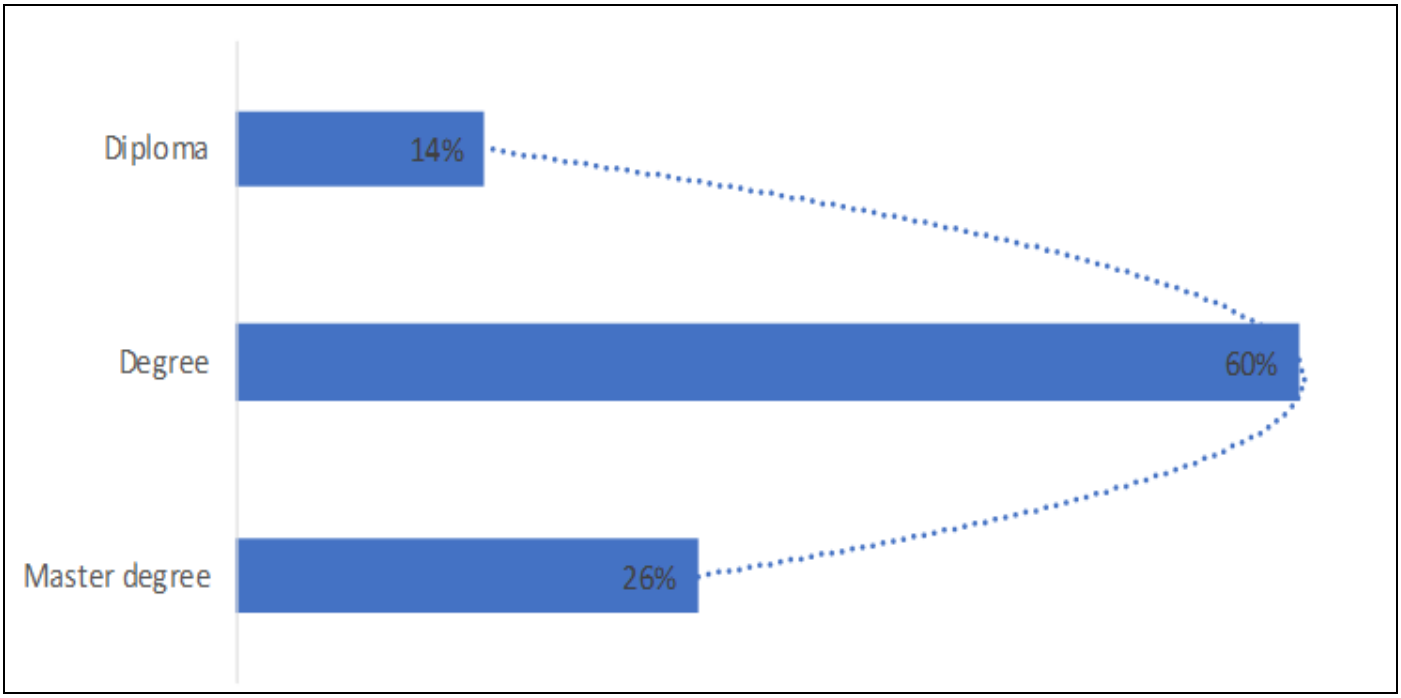

Fig 4 Education Levels of Respondents.

The qualifications of respondents show that the majority (60%) hold a bachelor's degree, followed by 26% with a master's degree, and 14% with a diploma. This distribution indicates that most respondents possessed academic expertise while high proportion of degree and master's holders suggests that the study benefited from well-informed insights on the technical, managerial, and environmental aspects of the Kafue Hook Bridge project.

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➢ *Presentation of Results Based on Objective One.*

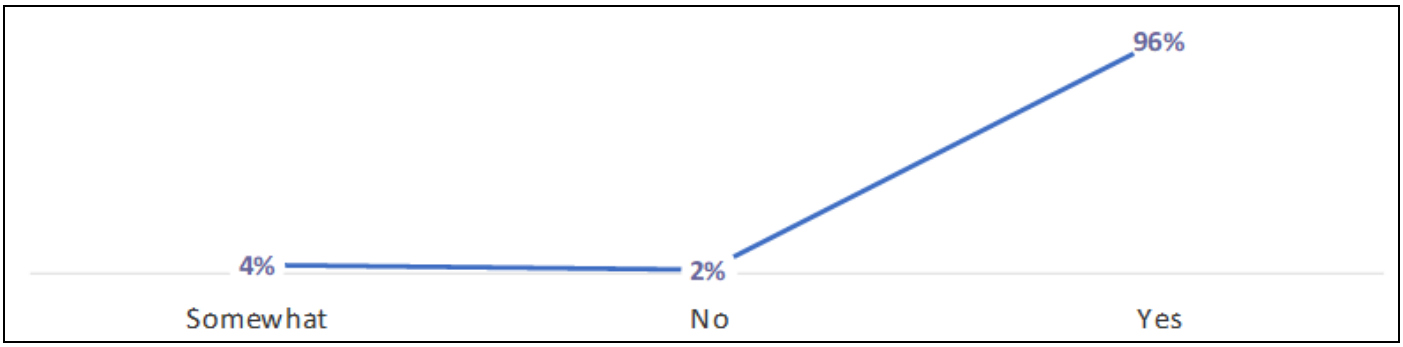

Fig 5 Familiarization of Respondents with Concept of Green Building Practices.

The results above reveal that 94% of respondents are familiar with the concept of green building practices, small proportion (4%) are somewhat familiar, suggesting room for further clarification or training, while only 2% are unfamiliar. This high level of familiarity highlights a strong foundation for implementing sustainable construction techniques.

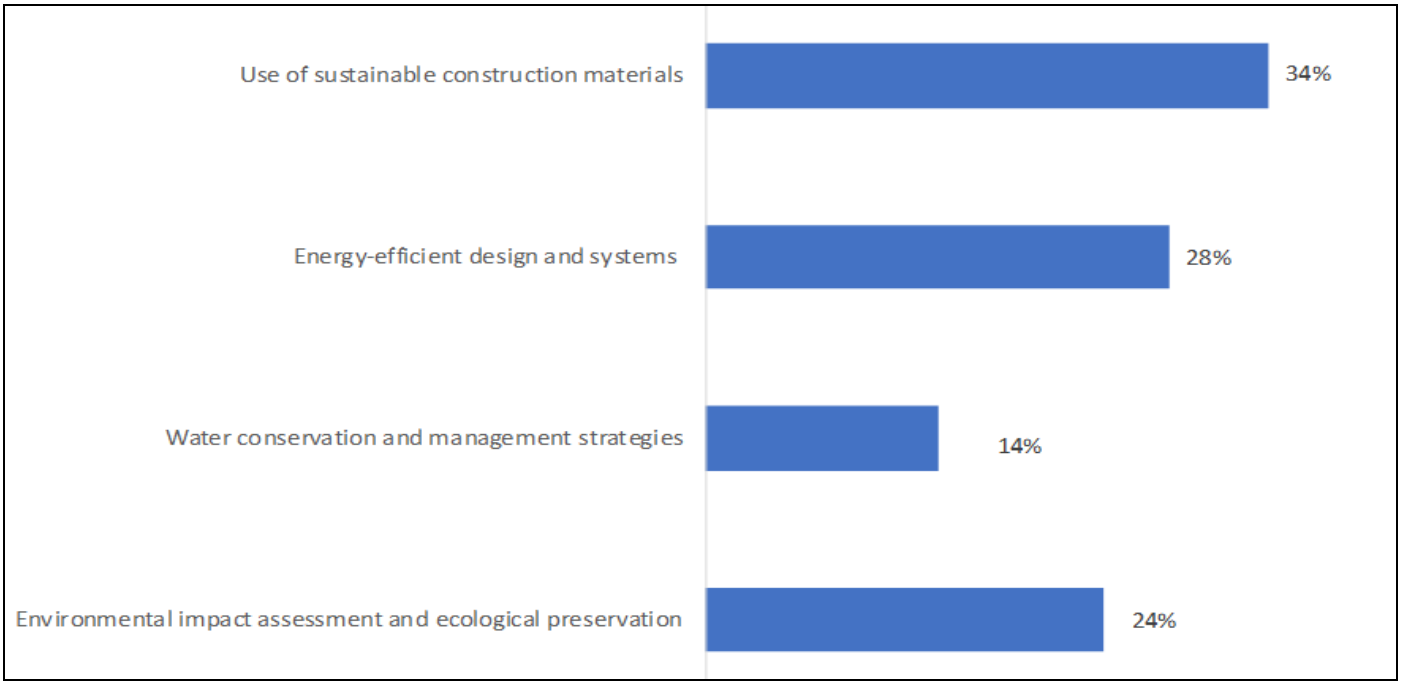

Fig 6 The Green Building Practices Implemented in Kafue Hook Bridge Project

The figure above suggests that 24% of respondents highlighted the environmental impact assessment and ecological effects, 14% mentioning water conservation and management strategies. 28% attributed to energy-efficient designs and 34% mentioned the use of sustainable construction materials also being significant practices. These findings directly contribute to establishing the green building practices applied in the project.

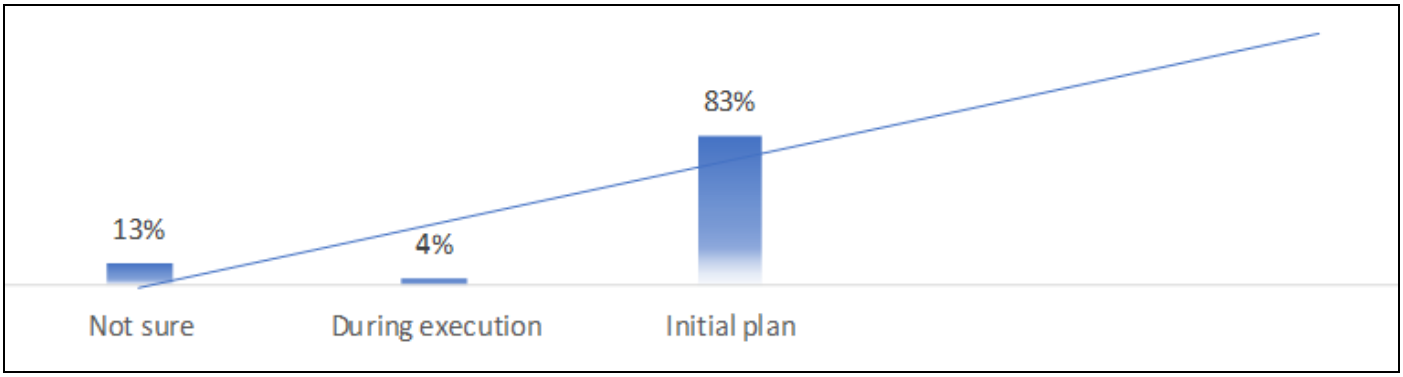

Fig 7 Green Building Practices as Part of Initial Project Plan

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The findings review that 83% of respondents indicated green building practices were part of the initial project plan, reflecting a proactive approach to sustainability in the Kafue Hook Bridge project. Only 4% reported integration during execution, suggesting minimal retrofitting of green practices after project commencement. Meanwhile, 13% were unsure, highlighting potential gaps in stakeholder communication or awareness during planning.

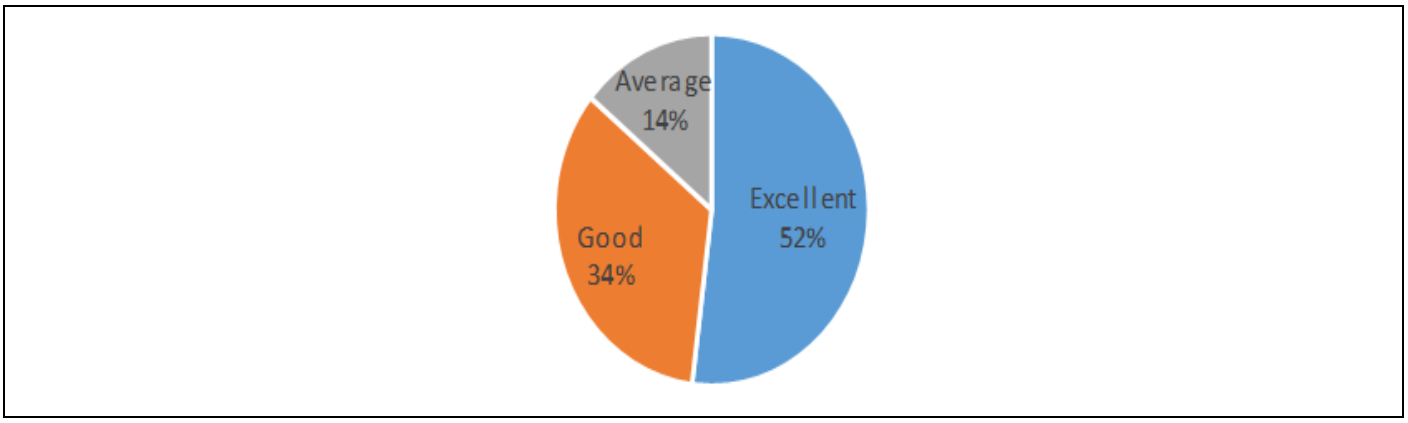

Fig 8 The rate of Integration of Green Building Principles in Kafue Hook Bridge Project

The figure shows that 52% of respondents rated the integration to be excellent, 34% rated it as good, and only 14% rated it as average. This highlights that green building practices were effectively integrated, supporting the objective of establishing their application in the project.

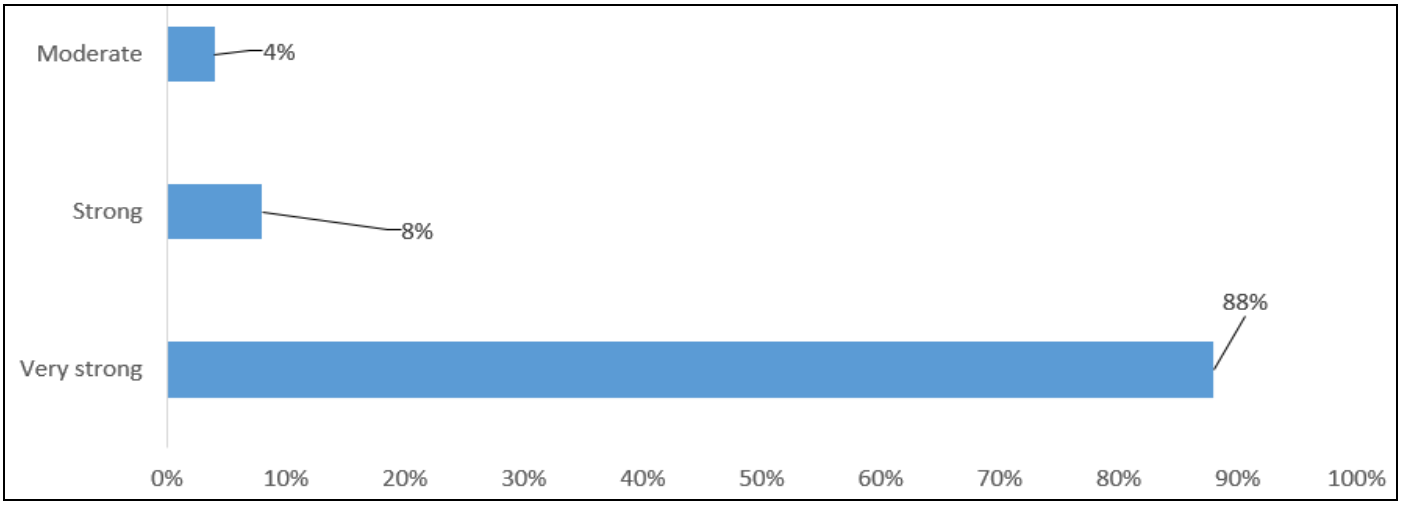

Fig 9 Regulatory Guidelines on Implementation of Green Building Practices in the Project.

The results tells that the regulatory guidelines had a very strong influence (88%). A smaller proportion (8%) felt the influence was strong, while only 4% reported a moderate influence.

➢ *Presentation of Results Based on Objective Two*

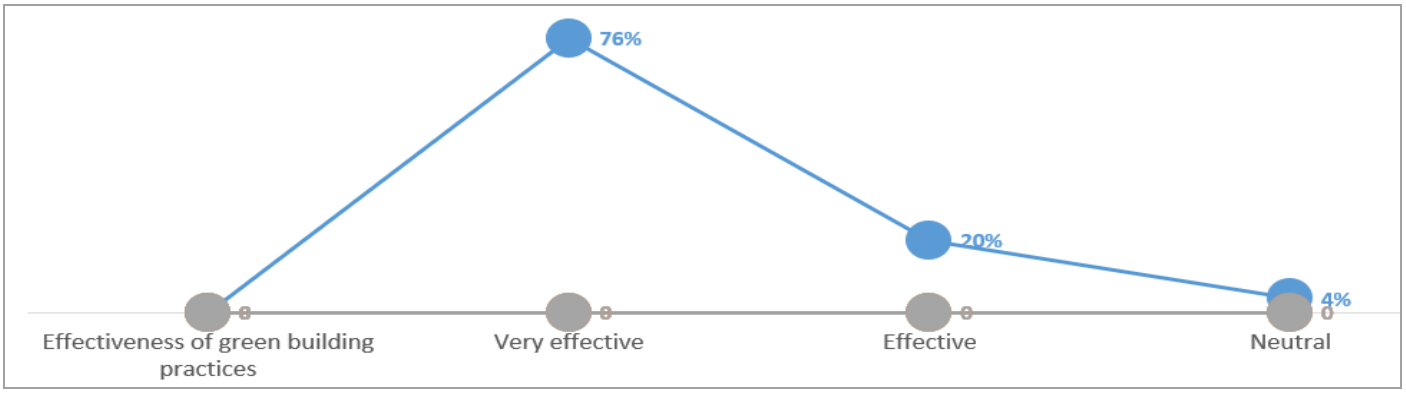

Fig 10 Effectiveness of Green Building Practices in Achieving Sustainability Goals.

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Figure 10 suggest that a significant 76% of respondents believed the green building practices implemented were very effective in achieving sustainability goals, while 20% found them effective, and 4% had a neutral view. These findings align with the objective of determining the effectiveness of green building practices in the project.

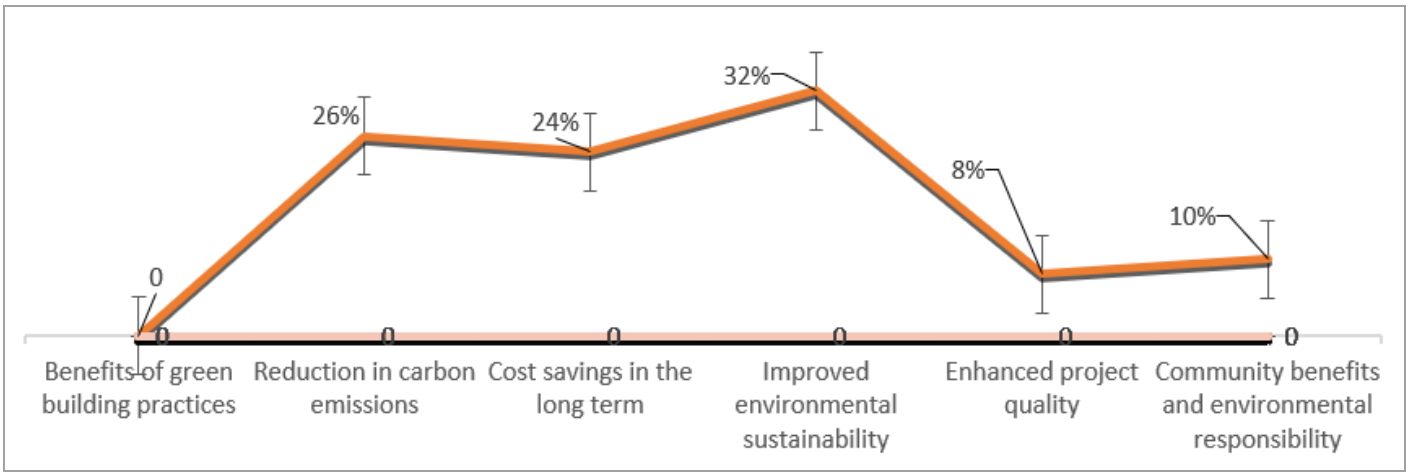

Fig 11 Advantages of Applying Green Building Principles.

The findings above highlights the key benefits of the green building practices, with 32% of respondents noting improved environmental sustainability, 26% citing reduced carbon emissions, and 24% mentioning long-term cost savings. (10% and 8%) recognized community benefits and enhanced product quality. These findings indicate the significant positive effects of the green building practices on environmental and economic outcomes.

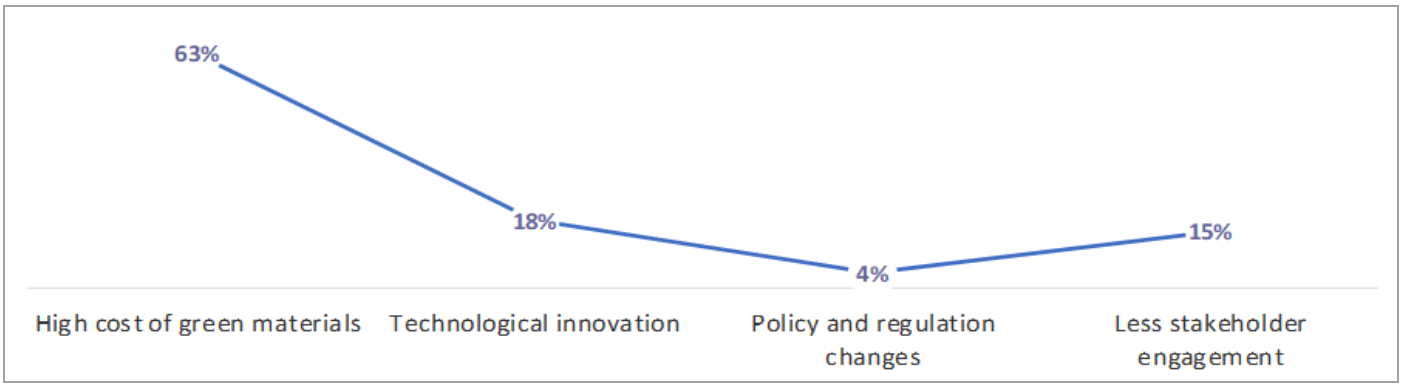

Fig 12 Trade-offs Observed Between Green Building Practices and Project Objectives.

The results suggest that 63% of respondents identified high costs of green materials as a significant trade-off in the project, followed by 18% who noted technological innovation as a trade-off. Proportions of (15% and 4%) pointed out less stakeholder engagement and policy/regulation challenges.

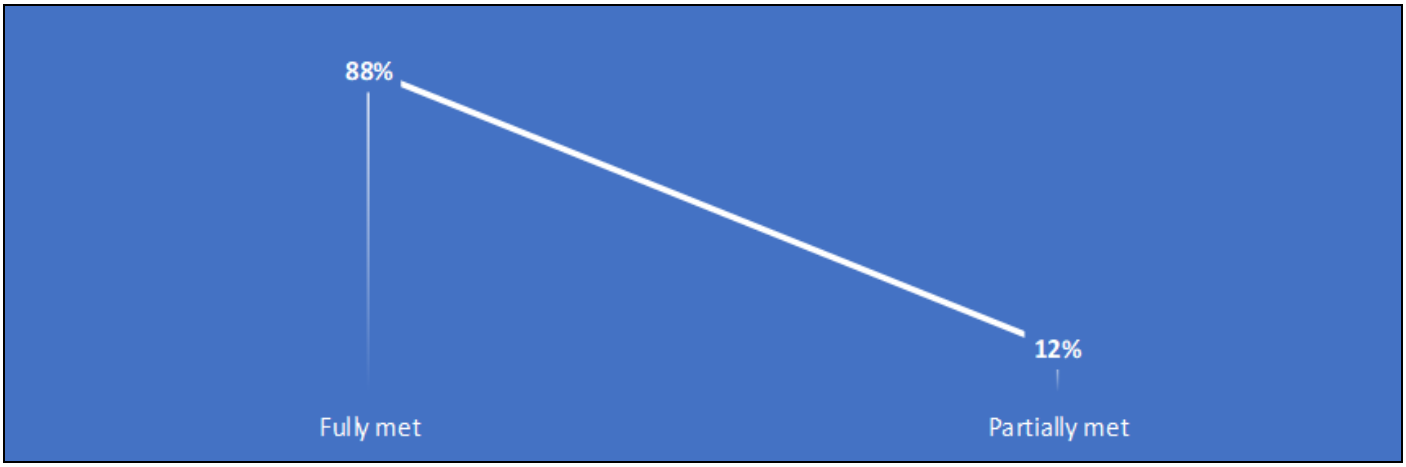

Fig 13 Project Meeting its Green Building Objectives.

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Results review that 88% of respondents believed that the project fully met its green building objectives with 12% reported that the objectives were only partially met.

➢ *Presentation of Results Based on Objective Three*

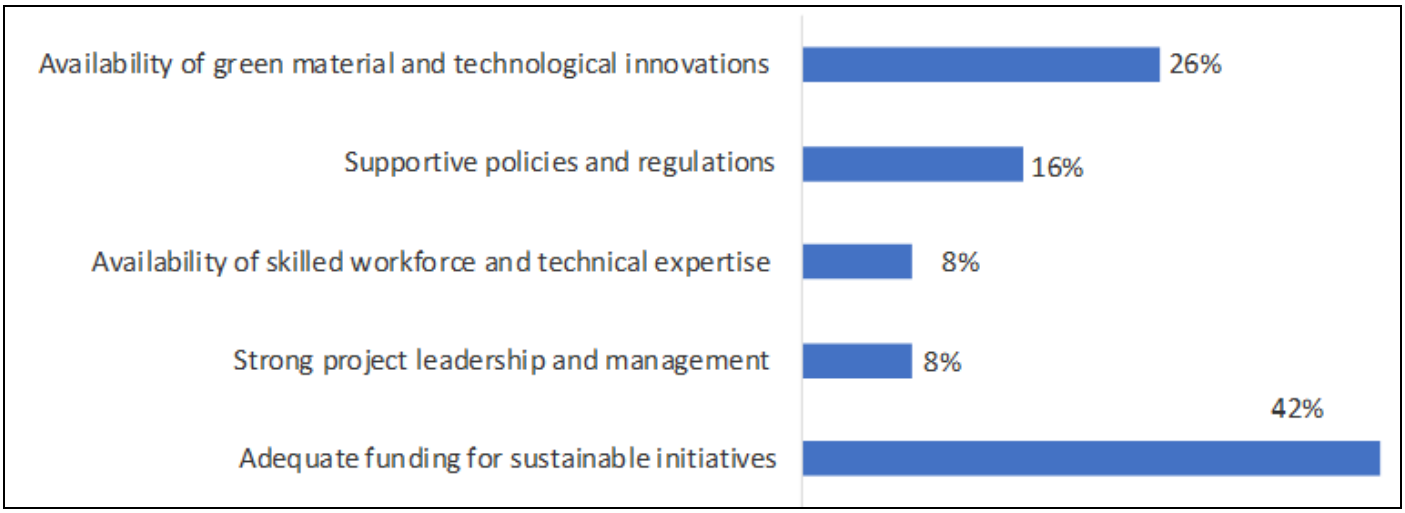

Fig 14 Factors Contributed to Successful Implementation of Green Building Practices.

Results highlight that adequate funding for sustainable innovation (42%) was the most significant. Availability of green materials and technological innovation (26%), supportive policies and regulations (16%) and strong leadership and skilled workforce each accounted for 8%.

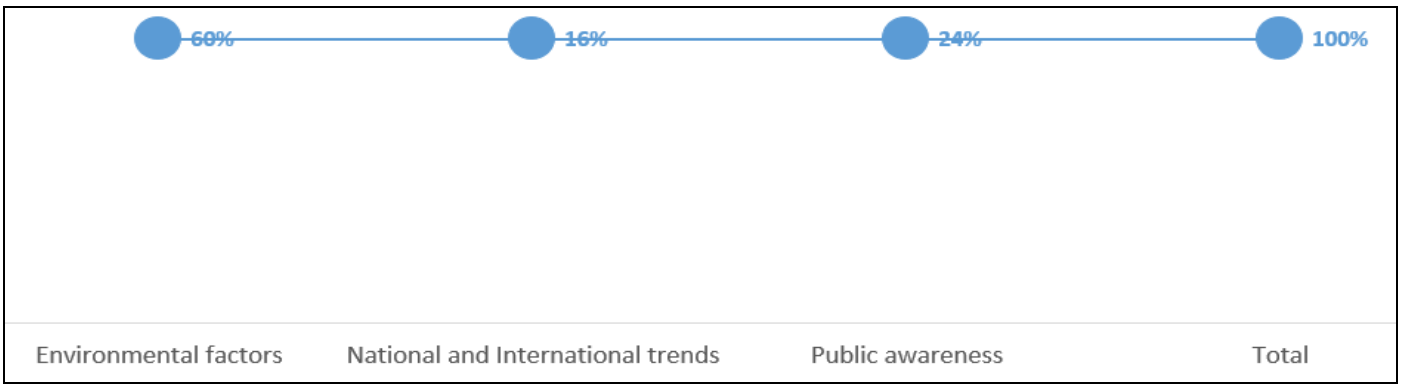

Fig 15 External Factors Influenced the Adoption of Green Practices.

The figure above shows that environmental factors (60%) were the most influential external drivers for adoption of green building practices in the project. Public awareness accounted for 24%, while national and international trends (16%) had a moderate influence.

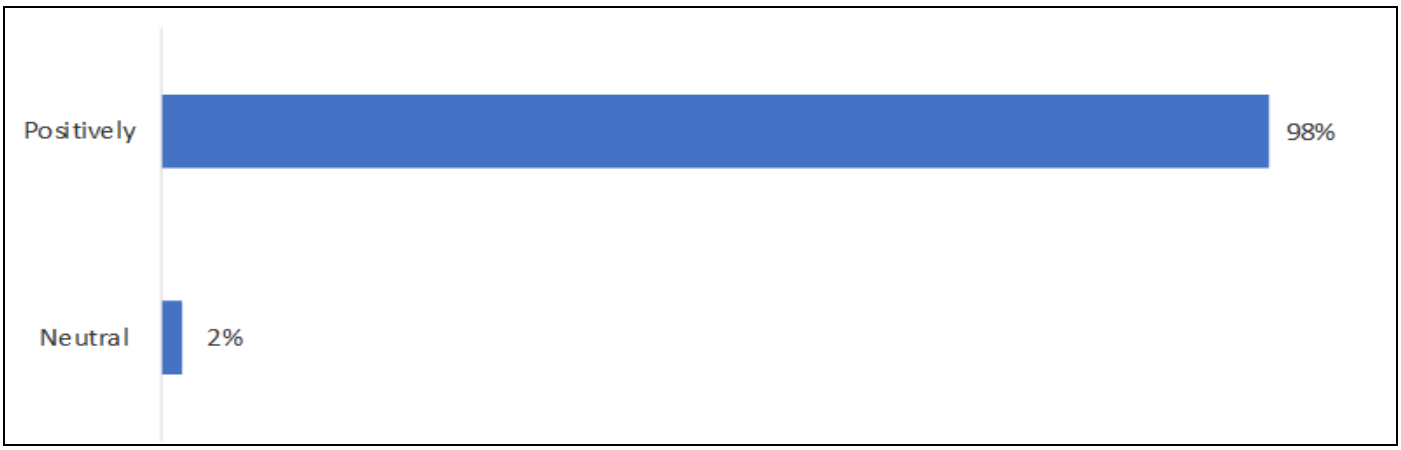

Fig 16 Effects of Resources Availability on the Success of Green Building Practices.

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The findings explain that 98% of respondents believe resource availability positively contributed to the success of green building, while only 2% held a neutral view.

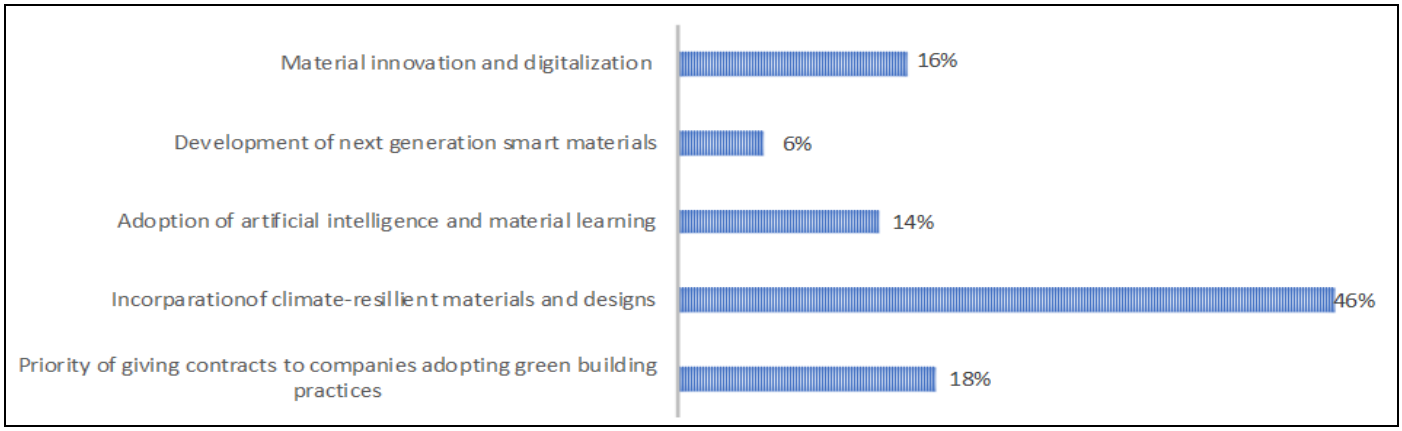

Fig 17 Factors Leading to Improvement of Green Building Practices in Future Projects.

Results suggest that incorporating climate-resilient materials and designs (46%) was critical factor for improving green building practices in future projects. Other significant factors include prioritizing contracts for companies adopting green innovations (18%) and material innovation and digitalization (16%). Adoption of artificial intelligence and material learning (14%) while 6% accounted for development of next generation smart martials.

➢ *Presentation of Results Based on Objective Four*

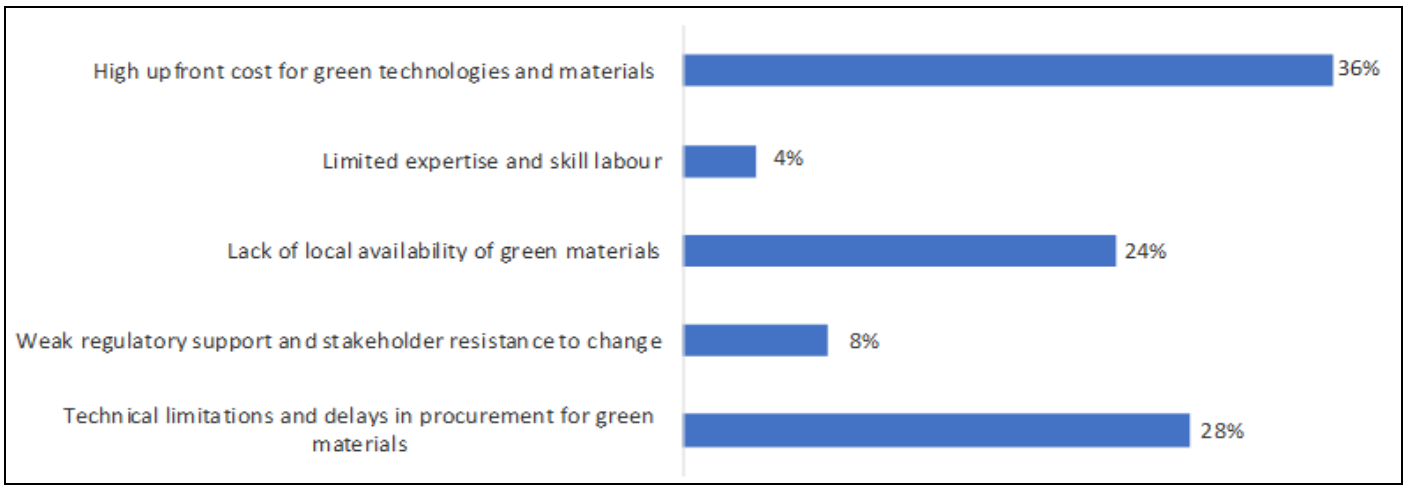

Fig 18 Challenges Encountered During Implementation of Green Building Principles in Construction of the Project.

The results showed that most of the respondents felt that the most significant challenge was the high upfront cost of green technologies and materials (36%), followed by technological limitations and procurement delays (28%) and lack of locally available green materials (24%). Limited expertise (4%) and weak regulatory support (8%) also affected implementation of (GBP).

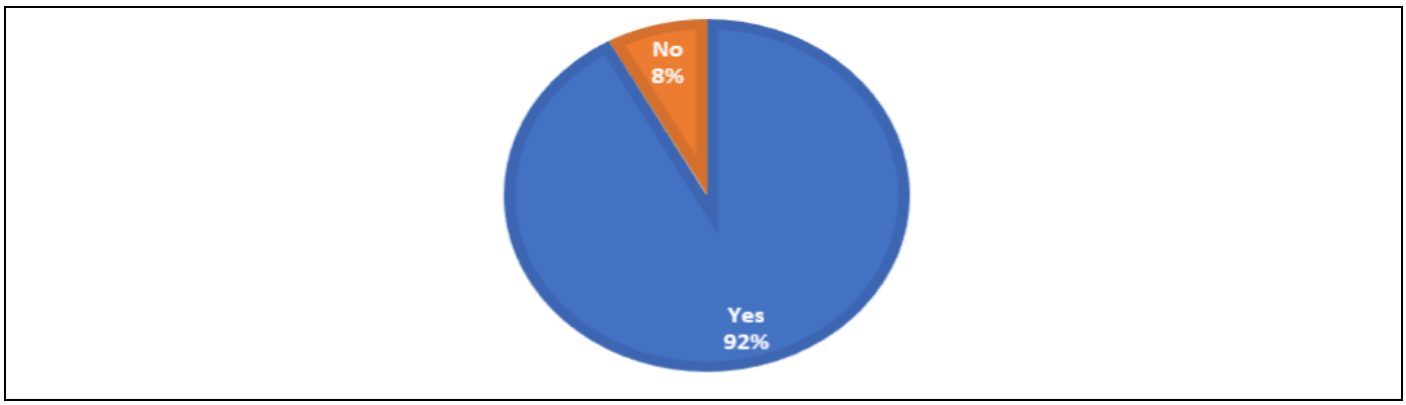

Fig 19 The Delays/Cost Overruns Attributed to Implementation Green Building Practices.

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The results reveal that a significant majority of 92% reported delays or cost overruns because of implementation of green building practices, while only a small portion of 8% disagreed.

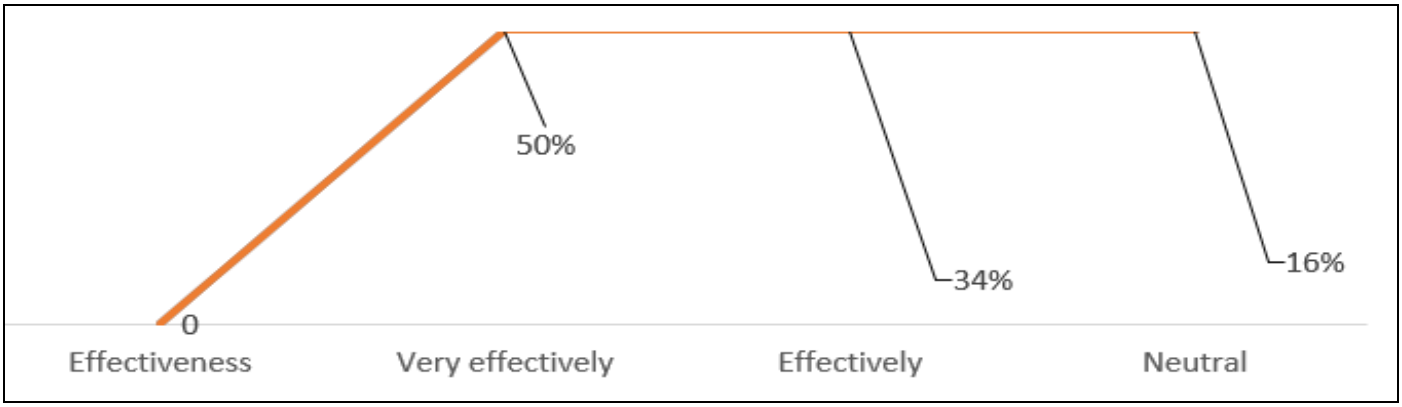

Fig 20 The Effectiveness in Addressing Challenges Encountered During Construction the Project.

The figure explains that 50% of respondents felt the challenges encountered during the construction of the project were addressed very effectively, while 34% believed the response was effective. However, 16% remained neutral on the matter.

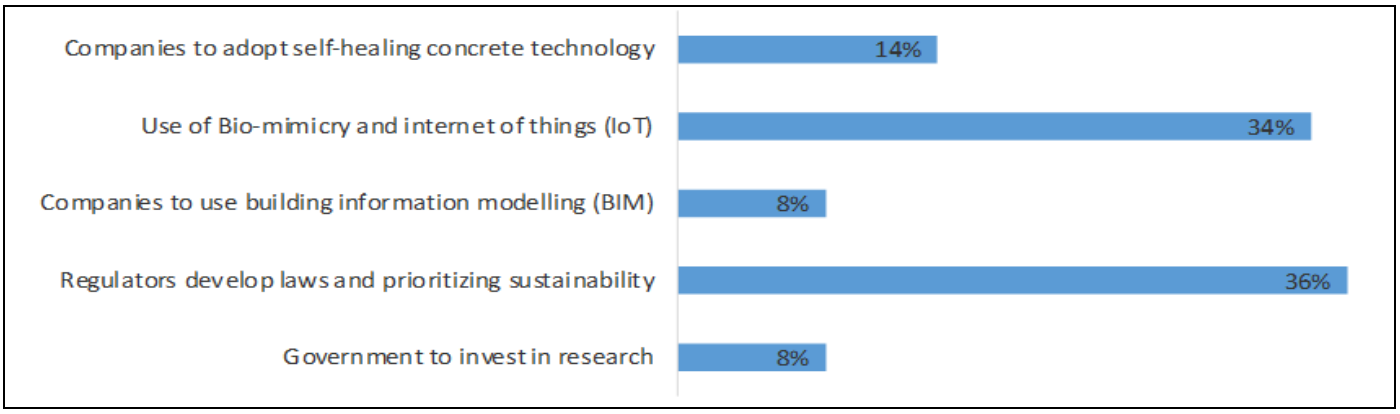

Fig 21 Recommendations for Improving the Implementation of Green Building Practices in Zambia's Constructions Sector.

The findings suggest that a significant portion of respondents (36%) recommended that regulators should focus on developing clear laws and prioritize sustainability, 34% of respondents emphasized the adoption of technologies like Biomimicry and the Internet of Things (IoT). Additionally, 8% called for government investment in research and for companies to explore advanced technologies such as Building Information Modelling (BIM) and 14% called for self-healing concrete.

➢ *Discussion of the Research Findings*

The Kafue Hook Bridge project's study on green building techniques examined a wide range of respondents, including Project specialist, engineers, architects, environmental specialists and procurement specialists. Engineers (26%) and environmental specialists (30%), in particular, were well-represented. The majority of respondents (94%) showed that they were aware with green building practices (GBP), which made it possible to identify important tactics including water conservation, energy-efficient design, and environmental assessments. Most (83%) said that GBP should have been included in the original project concept, and 88% agreed that regulatory frameworks are essential for adoption. The project met its sustainability goals, and 76% of respondents agreed that GBP had a major impact on cutting carbon emissions, enhancing sustainability, and saving money. But there were some noteworthy obstacles, such as high upfront expenditures (59%), technological limitations (28%), and a lack of locally available green materials (24%).

Stakeholder participation (76%) and resource availability (98%) were critical success elements, whereas enough finance (42%), the availability of green materials and technologies (26%), and supporting policies (16%) were important success factors. 50% of respondents indicated that issue resolution was very effective despite difficulties. Future project recommendations had a strong emphasis on digital tools like Building Information Modelling (BIM), climate-resilient designs, and cutting-edge technologies. In order to support sustainable building practices in Zambia and emerging economies, the study emphasized the necessity of striking a balance between costs, innovations, and stakeholder participation. Cost savings, long-term sustainability effects, and increased stakeholder involvement should be the main area of interest of future research.

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V. CONCLUSION AND RECOMMENDATION

➢ *Conclusion*

The Kafue Hook Bridge project demonstrated the effective incorporation of eco-friendly construction methods, supported by stakeholder cooperation (76%) and resource accessibility (98%), fulfilling its sustainability goals (88%). Nonetheless, obstacles like elevated material expenses (36%) and technological constraints (28%) posed considerable challenges.

➢ *Recommendations*

To tackle these issues, the research suggested improving stakeholder cooperation through workshops and collaborative planning meetings and channelling resources into research for creating affordable, locally sourced green materials and technologies such as BIM and IoT. Policymakers need to create specific regulations that encourage sustainability through compliance incentives. Furthermore, utilizing climates resistant materials and designs while educating industry experts on sustainable innovations is crucial for enhancing project results and ensuring long-term environmental sustainability. These actions can improve the scalability and effectiveness of sustainable practices in Zambia's construction industry.

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