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Sustainable Construction Practices in Building Infrastructure Projects: The Extent of Implementation and Drivers in Malawi

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Abstract: Sustainable practice is considered a significant practice in modern construction for infrastructure development as it promotes economic growth and improves quality of life. Despite the importance of sustainable practices in construction, few studies have explored the implementation of these practices in low-income countries like Malawi. Therefore, this study aims to assess the extent of the implementation of sustainable construction practices (SCPs) in building infrastructure projects in Malawi. Following an in-depth literature review, 22 sustainable construction practices and 13 drivers were identified. A survey of 193 construction professionals was conducted, and the data were analysed using descriptive statistics and the Relative Importance Index (RII). The findings revealed that economic practices such as efficient allocation of resources, use of quick construction tools and a coordinated supply chain in the construction process are widely implemented with emphasis on the economic aspect of sustainability for infrastructure projects in Malawi. The study further identified global trends and industry standards, social and health benefits, market demand and awareness and access to green technologies and innovation as the main drivers for adopting and implementing SCPs in Malawi. This study provides policymakers and stakeholders with valuable insights to develop policy regulations that would improve the sustainability performance of infrastructure projects.

Keywords: sustainable practices; drivers; building infrastructure projects; Malawi

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1. Introduction

The increasing concern about the adverse effects of construction, with buildings and construction activities accounting for over 36% of energy used globally and 39% of carbon dioxide (CO_2) emissions, requires the construction industry to develop solutions to create a sustainable built environment [1]. As a result, many governments and industry professionals across the globe have called for sustainable practices to be implemented in the construction sector. Sustainable practices in infrastructure projects contribute significantly to economic, social and environmental benefits [2].

Additionally, with a growing population and increasing urbanisation, the demand for infrastructure has increased exponentially across all sectors [3]. This has called for an urgent need to adopt construction practices that emphasise the efficient and effective utilisation of resources and the long-term health of our planet and its inhabitants across various fields. Moreover, in today's modern construction practices, sustainable practices have been identified as essential for infrastructure development, promoting economic growth, improving citizens' well-being and playing a significant role in achieving sustainable development [4]. However, most infrastructure projects in Malawi are carried out without adequate integration of sustainability practices in the construction process, negatively affecting project performance [5]. For instance, the recent Tropical Storm Gombe and Tropical Cyclone Freddy, which resulted in more damage to building infrastructure in Malawi, is reported to have been attributed to unsustainable construction practices such as unregulated land use and construction practices that consume excessive amounts of raw materials, energy and water [6,7]. Despite the numerous studies [8–11] on sustainability issues in developing countries, few studies have investigated the implementation of sustainable construction practices in building infrastructure projects in low-income countries like Malawi. Therefore, this study aims to assess the extent of implementation of sustainable construction practices in building infrastructure projects in Malawi. The study seeks to achieve this aim by (1) determining the sustainable construction practices adopted and implemented in the Malawian construction industry and (2) identifying the key drivers that will increase the adoption of sustainable construction practices in the construction industry.

2. Literature Review

2.1. Overview of the Malawian Construction Industry

The construction industry in Malawi plays a critical role in socio-economic development. The sector encompasses the construction and maintenance of various socio-economic infrastructure such as roads and bridges, buildings, water and sanitation and energy infrastructure. Infrastructure development measures the well-being of the nation's citizens [12]. Most developing countries, like Malawi, mainly rely on conventional methods when it comes to construction due to limited access to modern technologies, high-cost modern construction methods and limited financial resources. This makes the usage of modern techniques more challenging.

Moreover, traditional approaches to project outcomes heavily depend on skills and resource availability [13]. According to the Government of Malawi (2023), the infrastructure sector requires USD 161.21 million to construct and rehabilitate primary and secondary infrastructure after the devastating effect of Cyclone Freddy. However, the lack of these resources negatively affects the country's economy. According to the Malawi National Construction Industry Council, the construction industry accounted for 3.6% of Malawi's GDP in 2022, and the government has set a goal to increase this contribution to 10% by 2025. Previous studies indicate that implementing effective and efficient construction operations can contribute substantially to the overall economic growth of a nation [8,14,15].

Furthermore, the construction industry in Malawi has faced several challenges that have affected its growth and efficiency. Limited access to finance, inadequate infrastructure and a shortage of skilled labour have been the persistent challenges faced [16]. The industry heavily relies on foreign direct investment and development aid to fund significant projects, which often come with constraints and conditionalities, affecting the pace of project delivery [17]. Notwithstanding these obstacles, the construction industry has been instrumental in the country's development. It has contributed significantly to job creation, skills development and overall infrastructure improvement [18]. Edriss and Chiunda [19] opined that the industry has witnessed notable achievements, such as the construction of major road networks, the expansion of electricity generation capacity and the establishment of modern healthcare facilities. However, concerted public and private sector efforts are necessary to further drive the industry's growth and address the prevailing challenges.

Moreover, Nkado et al. [20] highlighted that the current construction practices utilised in nations with low- and middle-income populations are majorly conventional. In the case of Malawi, 90% of building structures are constructed using traditional materials, with a notable transition from mud wall construction to the use of burnt clay bricks observed in the last twenty years [21]. The burnt clay brick-manufacturing process requires only a limited number of resources, with the main components being clay, sand and wood for burning. These materials are less expensive and easily accessible. Clay is abundant in several areas in Malawi, particularly in Chembe in the Mangochi district, where a large clay deposit provides an almost unlimited supply of clay for local brickmakers. As a result, most contractors and clients extensively employ fired clay bricks in residential and commercial infrastructure while exhibiting reluctance towards adopting sustainable alternatives such as prefabricated concrete blocks and other advanced building materials [22]. According to Ngwira and Watanabe [23], burnt clay bricks are extensively utilised throughout Malawi. The burning procedure involves wood collection, which significantly contributes to deforestation. Although the raw materials for clay bricks are widely available, the burning process used to strengthen them is costly, inefficient and demands significant quantities of wood. Exploiting natural resources for conventional construction materials, like timber, burnt clay bricks and thatch, has significant negative effects on the country's forest reserves. To tackle these challenges, advancements in building technologies such as nanotechnology for steel frame construction, green building, precast concrete and the utilisation of recycled building materials which are socially, economically and environmentally sustainable should be adopted [22,24].

Furthermore, proposals for enhanced construction methods and materials have been made by [5] to reduce the devastating effects of traditional construction methods and materials on society, the economy and the environment. Nevertheless, the feasibility of these prospective solutions has been restricted due to the substantial capital involved, extended payback periods and inadequate government support [5]. In 2018, the Malawian government introduced the Sustainable Construction Materials Regulations, which banned the use of fired clay bricks in commercial and public construction projects. This policy was introduced to encourage the use of construction processes and materials that are environmentally friendly and have a lower impact on the planet. However, the enforcement of these restrictions and the implementation of an additional prohibition on unsustainable construction practices have been impeded by inadequate enforcement and a scarcity of practically viable alternatives in the country. Therefore, there is a need to strengthen enforcement mechanisms, thus necessitating the establishment of an independent regulatory body with the authority to monitor, inspect and enforce compliance [25]. According to Schnurr et al. [26] integrating sustainable construction practices into national development plans and policies and implementing incentives and penalties would promote compliance.

2.2. Sustainability in Construction

Sustainability is a broad concept that includes various important aspects on a global scale, such as ethical considerations, rules and guidelines that influence decision-making in organisations [27]. The Brundtland Commission in 1987 defined sustainability as the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability encompasses effectively managing structures, organisations and resources to meet current and future demands while addressing challenges that may arise in the short and long term [25]. Therefore, the sustainability of infrastructure needs to be prioritised at the initiation stage of the project as it directly affects overall project performance. The triple-bottom-line concept proposes that sustainability in construction may be attained by ensuring that project delivery meets environmental, social and economic performance [28]. Furthermore, the broad understanding of the concept of sustainability has led to new concepts and terms, such as sustainable construction practices, green building, etc., in response to the continuously evolving developments [29].

According to Du Thomas et al. [30], sustainable construction encompasses an integrated approach that seeks to establish and maintain a balance between the built and natural environments. Furthermore, it aims to develop infrastructure that upholds human dignity and promotes equitable economic growth. When a building or piece of infrastructure is constructed sustainably, it effectively meets the demands of current and future generations. According to Omopariola et al. [31], sustainable construction seeks to develop infrastructure that is in tune with the environment, improve the well-being of all people and advance economic equality, adapt to shifting needs and preferences, foster desirable social and natural environments and maximise resource use while reducing waste. To achieve such objectives, a comprehensive approach to construction design, execution and operation is necessary. The approach should consider the interconnected nature of economic, environmental and social factors and strive to achieve equilibrium among them. This entails developing projects that incorporate sustainability principles at every stage of the construction process while maintaining resilience in the face of adverse climatic conditions [32]. To achieve sustainable construction in the industry, there is a need for a multidimensional approach to construction with the triple-bottom-line (TBL) approach, which aims to strike a sustainable balance between the three dimensions [32]. The triple-bottom-line approach of sustainability is a framework introduced in 1994 that seeks to minimise the environmental impact of organisational activities, promote social cohesion and ensure economic growth [33]. In construction, TBL sustainability is achieved through three primary performance measures, which are environmental measures, which address the issue of waste management, resource conservation and greenhouse gas emissions during construction and demolition; economic measures, which deal with low maintenance and lifecycle cost, energy consumption and return on investment; and social measures which deal with public safety, public health and social equity. The triple-bottom-line performance measures of sustainability in construction are summarised in Figure 1.

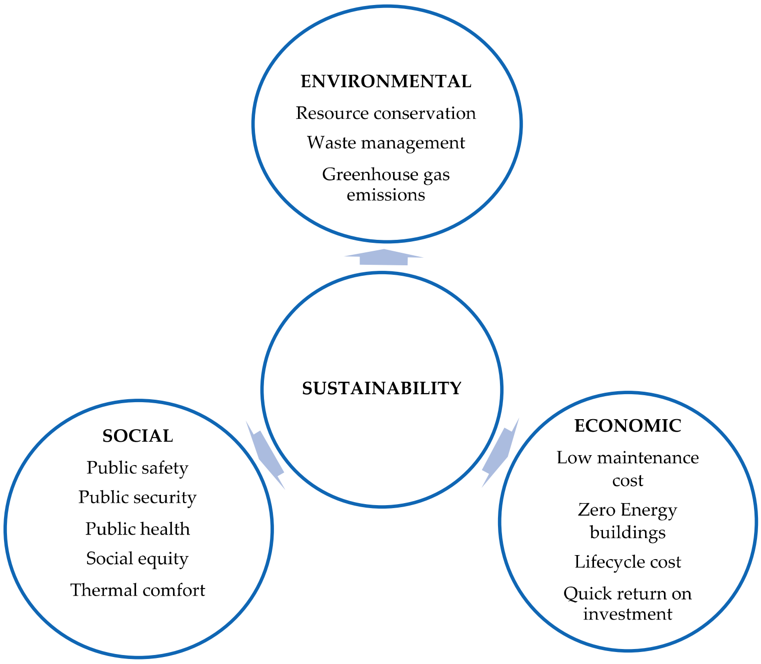

Figure 1. Triple-bottom-line performance measures of sustainability.

2.3. Sustainable Construction Practices

According to [34], sustainable practice is a qualitative or a quantitative characteristic applicable to infrastructure planning and delivery to achieve a sustainable goal. The authors identified sustainable practice as a measurable component under environmental, social and economic dimensions, which helps assess the sustainability of an infrastructure project. The study identified environmentally sustainable practices to include the use of waste reduction technologies in design and construction, less water consumption in design and construction and the use of low carbon emission equipment in buildings. However, the study failed to include issues of responsible land use and the use of locally manufactured construction materials, which are critical in regulating settlement and reducing carbon emissions. A study by Fatourehchi and Zarghami [35] identified socially sustainable practices, including the use of thermal insulation in buildings, socially inclusive designs and occupant health and safety quality performance. According to [36], implementing economic sustainability practices such as resource allocation, the use of automated systems in buildings and the use of quick construction tools in the construction sector contribute to cost reduction and improved project performance. It was discovered that most studies favoured the environmental aspect of sustainable construction compared to the social and economic aspects [37]. Moreover, sustainability practices in construction should include all of the sustainability dimensions [14]. According to [38], all sustainability aspects should be included in order to achieve a holistic, sustainable construction industry.

Furthermore, sustainable practices should be implemented in all construction projects throughout the inception, planning, execution, operation, maintenance and demolition stages [11]. Various studies have investigated sustainable practices according to project phases. However, this study considered the whole life cycle of the building project because considering the whole project life cycle will result in a more sustainable built environment. Several other studies [11,38–40] have identified sustainable practices for the construction of various infrastructure projects, including buildings and roads in different countries. However, sustainable practices obtained from these studies can be assessed by collecting data and interpreting them in the context of Malawi. Table 1 illustrates and summarises the sustainable construction practices for infrastructure projects obtained from the literature.

Table 1. Summary of sustainable construction practices from previous studies.

Categories	Code	Evaluation Items
Environmental	E1	Use of local and regional materials
	E2	Use of energy-efficient building materials
	E3	Use of waste reduction technologies in design and construction
	E4	Responsible land use, including protecting green places and reusing land
	E5	Use of less water consumption in design and construction
	E6	Use of renewable materials in buildings
	E7	Use of low carbon emission equipment in buildings
	E8	Use of recyclable building materials
Social		
	S1	Use of thermal insulations in buildings
	S2	Use of water-quality materials in buildings
	S3	Occupant health and safety quality performance
	S4	Adaptability in design and construction
	S5	Use of less noise equipment in construction
	S6	Use of indoor air quality materials in buildings
	S7	Socially inclusive designs
	S8	Acoustic and visual quality performance of the building
Economic		
	C1	Use of automated systems in buildings
	C2	Integration of building service in the construction process
	C3	Coordinated supply chains in the construction process
	C4	Proper implementation of an Asset Management Plan in buildings
	C5	Use of quick construction tools
	C6	Efficient allocation of resources

Table 1 shows the sustainable construction practices categorised according to the triple-bottom-line sustainability dimensions. It is important to note that not all practices obtained from previous studies are applicable in all contexts. Therefore, selecting a practice that is applicable to a specific study is best [41]. The criteria included practices applicable to the specific local circumstances, comprehensibility and data accessibility while ensuring that no essential practices were excluded [42]. Furthermore, Kapatsa et al. [11] opined that it is important to group sustainability practices based on clearly defined categories to easily select the practice for application where necessary. The categorisation was also based on emerging sustainability issues and trends, as shown in Table 1.

2.4. Drivers for the Adoption and Implementation of Sustainable Construction Practices (SCPs)

Many factors have influenced the evolution of the construction industry to a more sustainable built environment [43]. The term driver has different meanings among scholars in different sectors. According to [44] from a green building perspective, drivers are influencers that motivate and encourage the adoption of certain sustainable practices.

Regarding the factors that drive the adoption and implementation of SCPs in the execution of infrastructure projects in the construction sector, various factors have been identified depending on regional contexts and stakeholder priorities. Oke et al. [43] discovered the presence of supportive regulatory frameworks, building codes and policies as factors that encourage the adoption of sustainable construction practices in the Zambian construction industry. The formulation of policies, frameworks and building codes by government and industry professionals creates an environment that facilitates the adoption of SCPs. According to Sovacool and Del Rio [45], access to green construction materials, advanced technologies and expertise is essential for implementing sustainable construction methods and processes. This can be achieved by integrating these materials and technologies into construction projects, leading to more resilient and sustainable infrastructure projects.

Additionally, Saka et al. [46] opined that increasing market demand for sustainable and resilient buildings, driven by environmental concerns, energy efficiency goals and the desire for healthier and more comfortable living spaces, significantly influences the adoption of SCPs. Agyekum et al. [47] discovered that raising awareness, market demand and involving stakeholders in project planning and design encourage active participation and support for sustainable construction.

Moreover, demonstrating the financial benefits and long-term cost savings associated with sustainable construction processes and procedures is crucial for adopting SCPs [48]. Sustainable practices are characterised by higher initial costs, which often deter stakeholders from adopting these practices; however, they result in significant savings in the long- run from reduced energy consumption and lower maintenance costs [47].

Other significant factors include the availability of financial incentives, including subsidies and tax credits on sustainable processes and materials and adequate education and training programmes on sustainable practices [9,43,49]. Table 2 summarises the drivers for the adoption and implementation of sustainable construction practices obtained from the review.

Table 2. Summary of drivers for the adoption and implementation of sustainable construction practices (SCPs) from previous studies.

Location	Reference	Findings
Zambia	[50]	Education and training Long-term viability and affordability of sustainable technologies
Greece	[49]	Mitigating environmental risk Government regulatory compliance
Ghana	[47]	Market demand and awareness
Nigeria	[51]	Global trends and industry standards
Indonesia	[52]	Community and stakeholder engagement
International expert survey	[44]	Social and health benefits Presence of supportive regulatory frameworks Access to green technologies and innovation
UK	[53]	Supply chain consideration, Financial incentives and cost-effectiveness Company sustainability policy

3. Research Methodology

3.1. Research Design and Approach

The study adopted a quantitative research approach with a questionnaire as a data collection tool to obtain the opinion of construction professionals regarding the way professionals implement sustainable practices in carrying out infrastructure projects. The questionnaire was adopted because of its suitability in addressing the issue of time constraints and the large sample size of individuals providing the data for the study [40]. According to Liu et al. [54], a survey is deemed appropriate to answer what "type" research questions and studies involving large sample sizes.

Additionally, the study explored several literature sources related to the subject area obtained from academic databases such as Google Scholar, Web of Science, Scopus and Science Direct, which are considered to have a wide coverage of journal articles, conference papers and book chapters [55]. The review identified 22 sustainable practices and 13 drivers for the adoption and implementation of SCPs. These variables were coded into a questionnaire, and a pilot survey was conducted for experienced industry professionals to assess and validate the relevance, adequacy and clarity of the variables identified and provide feedback to help refine the questionnaire for onward distribution, thereby ensuring the reliability of the research instrument.

Respondents were requested to evaluate each of the variables using a 5-point Likert scale. The 5-point Likert scale was used because it allows the researcher to determine how strongly participants agree or disagree with statements on the scale and allows for ranking of responses in a 5-point format [56].

3.2. Population and Sampling

According to Denscombe [57], the population of a study comprises the entire set of individuals or groups included in research that can provide feedback or be assessed to accomplish the aim of a study. The population of the study was determined to be 938, comprising construction firms, consultants, specialist engineering firms and district councils obtained from the National Construction Industry Council 2023 register. However, considering cost and time constraints, dealing with the entire population would have been expensive and would require a significant amount of time. As a result, various strategies have been developed to allow the researcher to carefully and effectively target a segment of the population while accurately reflecting the characteristics of the entire population [56]. Using probability sampling, particularly stratified random sampling techniques, and with a confidence level of 95% and a margin of error of +/−5%, the sample size was determined to be 273 across all key stakeholder groups in the construction industry. According to Rahi [58] stratified random sampling techniques allow the researcher to select several samples representing each stratum of the population. It is also the most efficient sampling technique among all of the probability sampling techniques as it has a higher ability to generalise the research findings [59]. The sample size was determined using Cochran's formula:

$$n_0 = \frac{z^2 \times p \times q \times N}{e^2(N-1) + z^2 \times p \times q} \quad (1)$$

where n_0 = sample size

N = 938 (the population)

z =1.96 (standard variate value at the 95% confidence interval), p = 0.5, q = 0.5 ($1 - p$) and e = 0.05 (margin of error)

Therefore, the sample size (n_0) $= \frac{1.96^2 \times 0.5 \times 0.5 \times 938}{0.05^2(938-1)+1.96^2 \times 0.5 \times 0.5} = \frac{900.86}{3.303} = 273$.

The questionnaire was administered to 273 experienced construction professionals, including architects, project managers, civil engineers, quantity surveyors, electrical engineers, mechanical engineers, builders and procurement officers, with in-depth knowledge of sustainable construction within the Malawian construction industry. A total of 193 out of the 273 questionnaires administered were retrieved with a valid response rate of 71%. According to Baruch [60], a response rate of approximately 35% is satisfactory for most academic studies. Therefore, a response rate of 71% is acceptable and appropriate for the purpose of this study.

3.3. Method of Data Analysis

Using Statistical Packages for Social Sciences (SPSS) version 22 software, the quantitative data obtained were analysed using Cronbach's alpha, the Shapiro–Wilk normality test and descriptive statistics including mean, standard deviation and Relative Importance Index (RII). The Cronbach's alpha coefficient test was run to determine the internal consistency and reliability of the scale used to evaluate the variables. When Likert scales are used in a study, it is important to validate the reliability of the instrument used in rating the variables [61]. The reliability coefficient often falls within the range of 0 to 1. A higher alpha coefficient with a threshold value of 0.70 indicates that the criteria used in the scale is reliable and consistent [62].

The mean score was utilised to rank the SCPs adopted and implemented in descending order of importance under the three dimensions of sustainability. This approach was adopted by Zulu et al. [38] in ranking SCPs in the Zambian construction industry. The standard deviation of all of the variables was also included to measure the extent of variation or the extent of agreement among all of the construction professionals regarding the adoption and implementation of sustainable construction practices [63].

Furthermore, a percentage-weighted mean score was utilised to further determine the level of implementation of SCPs in Malawi. According to Zafar et al. [64], employing a weighted score facilitates an objective assessment of the subjective opinions of experts regarding a particular subject. Several studies have adopted the weighted score, a branch of fuzzy set theory, in the research domain. Osei-Kyei et al. [65] utilised a weighted score approach to evaluate critical success factors in the operational management of Public–Private Partnership projects. Similarly, this study employed a Percentage Weighted Mean Score (PWMS) in determining the level of implementation of SCPs in the Malawian construction industry. The PWMS was calculated using the following expression:

$$\text{Percentage Weighted Mean Score (PWMS)} = \frac{AMS_1}{AMS_1 + AMS_2 + AMS_3} \times 100 \quad (2)$$

where AMS = Average Mean Score (AMS_1, AMS_2, AMS_3,. . . . . .AMS_n).

Also, the Shapiro–Wilk normality test was employed to test for the normality of the data set and the appropriateness of the data for non-parametric tests. The Shapiro–Wilk normality test was utilised because of its suitability for sample sizes of less than 2000 [66].

Furthermore, the Relative Importance Index (*RII*) was used to further analyse the drivers for the adoption and implementation of SCPs. The *RII* was used in this study due to its ability to show the importance of some factors over others. Thus, employing the *RII* helps to identify the most critical factors by assigning indices to each factor under consideration [67]. The Relative Importance Index (*RII*) was determined using the following formula:

$$RII = \frac{\sum W}{(A \times N)} \quad (0 \leq RII \leq 1) \quad (3)$$

where W is the weight assigned to each factor by the respondents on a scale of 1 to 5, N is the total number of respondents and A is the highest response value (5 in this instance).

Descriptive statistics, including mean and standard deviation, were also included to check the indices from which the *RII* values were generated. When two or more variables have the same *RII* values, the variable with the lowest standard deviation is assigned the highest ranking [67].

4. Results and Discussion

4.1. Respondents' Demographic Information

The background information of the respondents obtained from the survey is presented in Figure 2. Regarding the level of education, the results showed that more than half of the respondents, 105 out of 193 (54%), obtained a minimum of a bachelor's degree, while only 4% had secondary qualifications. This indicates that stakeholders in the Malawian construction industry have attained a relatively high level of education. According to Marsh et al. [68], professionals with higher levels of education are more likely to understand and adopt advanced technologies and innovative green construction methods associated with sustainable construction. Therefore, the high level of education is significant for the adoption and implementation of sustainable construction practices in Malawi.

Also, most of the participants were architects, followed by project managers, civil engineers and quantity surveyors, with only 3% being procurement officers, which indicates that most building infrastructure projects are designed and constructed by professionals. According to [69], SCP requires the efforts of several actors who combine their expertise in the construction process to help accomplish the goal of a project. Hence, obtaining responses from all professionals within the construction industry will contribute greatly to achieving the aim of the study. In terms of experience, more than half of the respondents (62%) had more than 5 years of work experience. This suggests that most professionals in the construction industry in Malawi have acquired enough experience to enhance the adoption of sustainable construction practices.

Moreover, the respondents were from different organisations, with the majority (41%) from construction companies, 28% from consulting firms, 16% from real estate companies and 15% from government agencies. The results further indicate that the participants had significant experience working on building projects required to offer valuable information for the study.

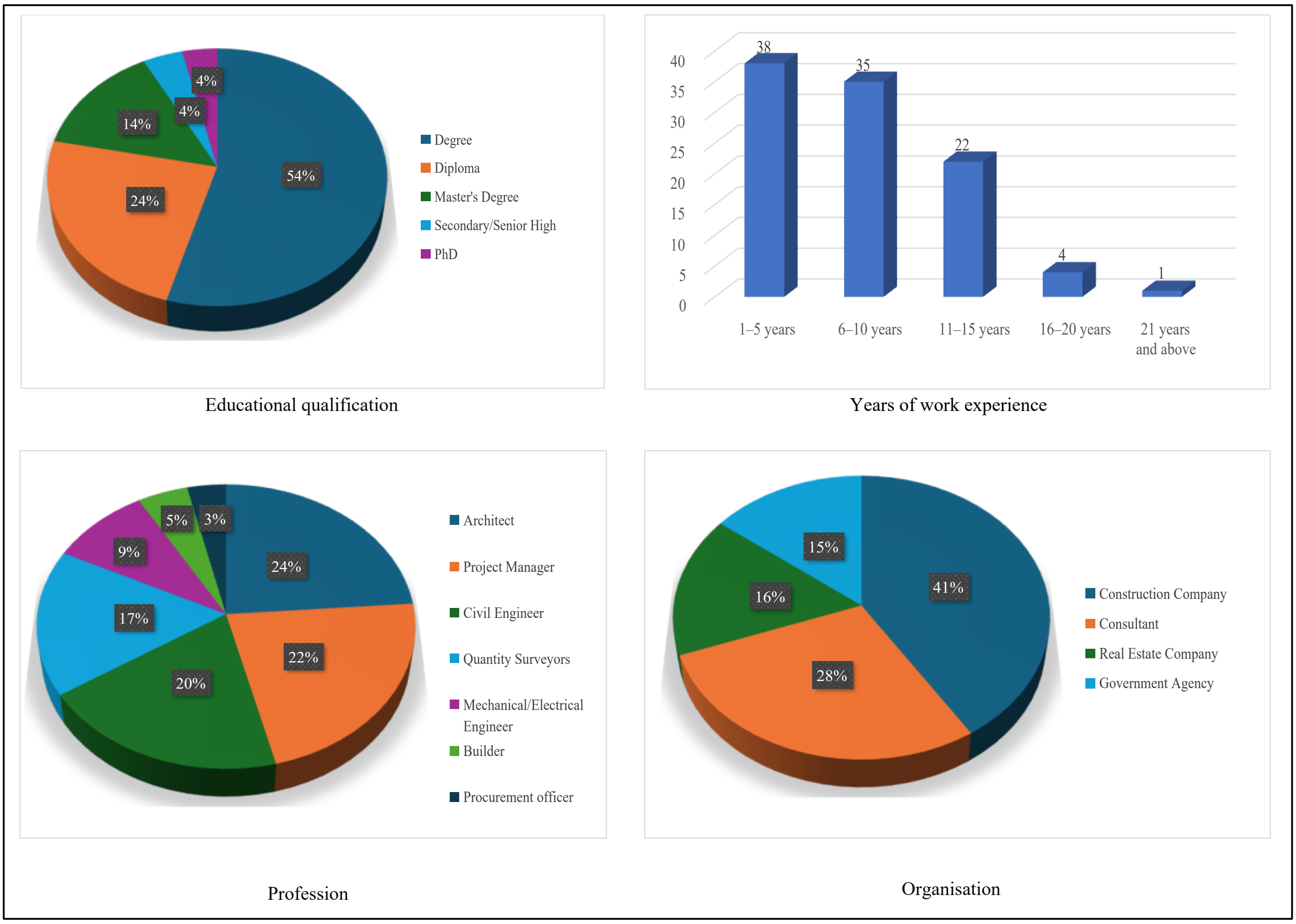

Figure 2. Demographics of respondents.

4.2. Ranking of the Sustainable Construction Practices (SCPs) Adopted and Implemented

The first objective was to determine the sustainable construction practices implemented in the Malawian construction industry. To achieve this, the study employed a decision-making approach similar to that of Zulu et al. [38] in ranking SCPs in the Zambian construction industry. Zulu et al. [38] used mean score ranking for each practice under the triple-bottom-line sustainability dimensions and ranked the overall dimensions based on dimensional means. Participants were instructed to assess the variables within each dimension using a Likert scale of 1 to 5, where 1 = never used, 2 = rarely used, 3 = occasionally used, 4 = frequently used and 5 = very frequently used based on their knowledge and observation in their various organisations during project execution.

A reliability test was conducted to check the internal consistency and reliability of the scale used to rate the various practices. The Cronbach's alpha reliability coefficient often falls between 0 and 1. A higher Cronbach's alpha value suggests high internal consistency and reliability of the criteria used in the scale [62].

Table 3 shows the Cronbach's alpha coefficient values for the environmental, social and economic practices, which were 0.900, 0.876 and 0.862, respectively. This shows that all of the Cronbach's alpha coefficients were greater than 0.70, indicating a higher level of reliability and excellent internal consistency of the criteria used in the scale. Therefore, the data under consideration were subjected to further analysis.

Table 3. Reliability test.

Categories	No_ of Items	Cronbach's Alpha (α)
Environmental criteria	8	0.900
Social criteria	8	0.876
Economic criteria	6	0.862
Overall	22	0.922

Additionally, the evaluation criteria of the level of adoption and implementation of SCPs was developed using the percentage-weighted mean score (PWMS) matrix. The resulting PWMS values were classified as initial ($0 \leq PWS \leq 20$), minimal ($20 \leq PWS \leq 40$), moderate ($40 \leq PWS \leq 60$), advanced ($60 \leq PWS \leq 80$) and full integration ($80 \leq PWS \leq 100$), as shown in Table 4. A similar approach was used by [65] to evaluate the critical success factors in the operational management of Public–Private Partnership projects.

Table 4. Percentage-weighted mean score matrix.

SN	Initial	Minimal	Moderate	Advance	Full Integration
Weighted score ratings	($0 \leq PWS \leq 20$)	($20 \leq PWS \leq 40$)	($40 \leq PWS \leq 60$)	($60 \leq PWS \leq 80$)	($80 \leq PWS \leq 100$)

PWS = Percentage-Weighted Score.

Furthermore, Table 5 summarises the descriptive statistical analysis (mean and standard deviation) of all of the variables and the percentage-weighted mean for each category computed using the average mean for each dimension. The purpose of the analysis was to provide a statistical model for evaluating the SCPs adopted and implemented and the level of implementation in Malawi. It is noteworthy to highlight that the standard deviations of all of the variables being analysed were less than one (<1), showing a high level of agreement among respondents regarding the variables with a lower degree of variation [70].

Table 5. Summary of the sustainable construction practices adopted and implemented.

Code	Sustainable Construction Practices	MS	SD	Rank	Weightings for Each SCP	Average Mean for Each Dimension	Weighted Score for Each Category (%)
	Environmental			3		2.65	30
E1	Use of local and regional materials	2.83	0.967	1	0.134		
E2	Responsible land use, including protecting green places and reusing land	2.81	0.988	2	0.133		
E3	Use of less water consumption in design and construction	2.75	0.937	3	0.130		
E4	Use of energy-efficient building materials	2.74	0.904	4	0.130		
E5	Use of low carbon emission equipment in buildings	2.71	0.859	5	0.128		
E6	Use of renewable materials in buildings	2.56	0.950	6	0.121		
E7	Use of recyclable building materials	2.41	0.986	7	0.114		
E8	Use of waste reduction technologies in design and construction	2.34	0.928	8	0.111		
	Social			2		3.04	34
S1	Occupant health and safety quality performance	3.19	0.876	1	0.131		
S2	Acoustic and visual quality performance of the building	3.15	0.924	2	0.129		
S3	Use of thermal insulations in buildings	3.09	0.940	3	0.127		
S4	Adaptability in design and construction	3.03	0.892	4	0.124		
S5	Use of indoor air quality materials in buildings	3.02	0.932	5	0.124		
S6	Use of less noise equipment in construction	2.98	0.973	6	0.122		
S7	Socially inclusive designs	2.97	0.865	7	0.122		
S8	Use of water-quality materials in buildings	2.91	0.891	8	0.120		
	Economic			1		3.28	37
C1	Efficient allocation of resources	3.42	0.933	1	0.174		
C2	Use of quick construction tools	3.34	1.044	2	0.170		
C3	Coordinated supply chains in the construction process	3.32	0.930	3	0.169		
C4	Proper implementation of an Asset Management Plan in buildings	3.23	0.901	4	0.164		
C5	Integration of building service in the construction process	3.20	0.881	5	0.163		
C6	Use of automated systems in buildings	3.18	0.941	6	0.162		

MS = mean score; SD = standard deviation.

From Table 5, a total of twenty-two practices were evaluated and ranked according to their mean score values. The mean score ranking was used to rate the sustainable practices that were most frequently adopted and implemented. The following sections are discussions of these practices.

4.2.1. Environmental

The environmental dimension in Table 5 consists of eight sustainable practices. From the findings, industry professionals generally rated these practices poorly in this dimension. From the results, the use of local and regional materials was highly ranked under this dimension, with a mean score of 2.83, followed by responsible land use, with a mean value of 2.81. This confirms the findings of Kloukinas et al. [21] that most of the building structures in Malawi are constructed using locally and regionally sourced materials, with a notable transition from mud walls to burnt clay bricks for the past decade. Jegede and Taki [71] opined that prioritising the use of Indigenous and regional materials in construction reduces transportation distances, thereby minimising the carbon footprint associated with construction projects. The use of waste reduction technologies in design and construction was the lowest ranked, with a score of 2.34. These findings, however, are contrary to the assertion of Liu et al. [54] who postulated that methods such as modularisation and the utilisation of precast concrete are well-suited for minimising waste.

Furthermore, the findings under this dimension indicate that environmental-related practices towards attaining sustainable building infrastructure are not highly prioritised during construction in Malawi, despite the importance of these practices in increasing building resilience to climatic shocks [72]. The findings also showed that the level of adoption and implementation of environmentally sustainable construction practices has been minimal, with a weighted score of 30%. There is a need for industry professionals to place more emphasis on and prioritise environmental practices in building infrastructure projects.

4.2.2. Social

The social dimension comprises eight practices, and the results show that the practices under this dimension were ranked low. Nevertheless, ensuring occupant health and safety performance of building infrastructure was ranked high with a mean of 3.19, followed by acoustic and visual quality performance of the buildings and the use of thermal insulation in buildings, with mean score values of 3.15 and 3.09, respectively. These findings agree with that of Arshad et al. [73] who emphasised that providing a safe and healthy indoor environment in buildings helps support public health and enhances the well-being of occupants. Proper ventilation and access to natural light contribute to the physical health of occupants [74]. On the other hand, the use of water-quality materials in buildings was the lowest ranked, with a mean of 2.91. The findings indicate that despite the impact of reduced water consumption and water conservation technologies on the operation cost of infrastructure projects, the level of implementation is still low in the Malawian construction industry.

4.2.3. Economic

Economic as a sustainability dimension has six practices, with mean values between 3.42 and 3.18. Efficient allocation of resources was ranked the highest, with a mean value of 3.42. This entirely reflects the situation in Malawi, where construction resources are limited [75]. The second- and third-ranked practices were the use of quick construction tools and coordinated supply chains in the construction process, with mean scores of 3.34 and 3.32, respectively. The lowest ranked variable was the use of automated systems in buildings. These findings confirm the findings of El Khatib et al. [76] in that implementing construction practices that prioritise economic sustainability ensures the timely completion of projects and adherence to the required quality standards. According to Ogunmakinde et al. [36], implementing economic sustainability approaches in the construction sector reduces costs and improves project performance.

Furthermore, from Table 5, the Percentage-Weighted Mean Scores suggest that the level of adoption and implementation is minimal, with the economic practices recording 37%, followed by the social practices at 34% and environmental practices at 30%. This implied that while the participants consider sustainability practices to be important, these practices are not frequently applied during project execution.

The findings were evident in pointing out that the economic aspect of sustainable construction was adopted and implemented more in the Malawian construction industry. However, less attention was given to the environmental and social aspects of SCPs in Malawi. In favour of the findings, Zulu et al. [32] discovered the implementation of economic and social sustainability practices in the Zambian construction industry. Moreover, the low level of adoption and implementation of environmental sustainability practices was evident in the destruction of building infrastructure in Malawi caused by Tropical Storm Gombe and Tropical Cyclone Freddy [77]. Overall, the level of implementation of SCPs in Malawi is minimal compared to other developing countries, ranging between 30% and 37%. Therefore, to achieve a holistic approach to sustainable construction, it is imperative to increase knowledge and awareness of the environmental and social aspects of sustainable construction.

4.3. Drivers of Sustainable Construction Practices

The second objective of the study was to determine the factors that drive the adoption and implementation of sustainable construction practices in Malawi. The Relative Importance Index (RII) method was utilised to rank the drivers of SCPs, which were obtained from the in-depth literature review and the survey conducted among professionals in the Malawian construction industry. The results obtained from the data analysis are presented in Table 6 and the findings are discussed in the following subsection. The Cronbach's alpha coefficient was also determined to be 0.916 for all of the variables, which is greater than 0.70, indicating a higher level of reliability and excellent internal consistency of the scale utilised [62].

Table 6. RII of the drivers of sustainable construction practices (SCPs).

							Shapiro–Wilk	
SN	**Factors**	**Mean**	**Std. Error Mean**	**SD**	**RII**	**Ranking**	**Statistic**	**Sig.**
1	Global trends and industry standards	3.90	0.054	0.757	0.779	1st	0.831	0.000
2	Social and health benefits	3.81	0.061	0.848	0.762	2nd	0.841	0.000
3	Market demand and awareness	3.80	0.054	0.754	0.760	3rd	0.806	0.000
4	Access to green technologies and innovation	3.79	0.056	0.776	0.759	4th	0.833	0.000
5	Education and training	3.79	0.060	0.830	0.758	6th	0.843	0.000
6	Supply chain consideration	3.79	0.055	0.765	0.758	5th	0.841	0.000
7	Presence of supportive regulatory frameworks	3.78	0.048	0.673	0.756	7th	0.749	0.000
8	Financial incentives and cost-effectiveness	3.77	0.051	0.709	0.753	8th	0.800	0.000
9	Community and stakeholder engagement	3.77	0.058	0.805	0.753	9th	0.779	0.000
10	Mitigating environmental risk	3.75	0.056	0.784	0.750	10th	0.823	0.000
11	Government regulatory compliance	3.71	0.054	0.756	0.742	11th	0.817	0.000
12	Long-term viability and affordability of sustainable technologies	3.69	0.059	0.826	0.739	12th	0.859	0.000
13	Company sustainability policy	3.61	0.057	0.790	0.722	13th	0.840	0.000

Std = standard; SD = standard deviation; RII = Relative Importance Index.

RII Ranking of the Drivers of Sustainable Construction Practices (SCPs)

Deducing from the information in Table 6, the Shapiro–Wilk test for normality showed that the significant values (p-values) of all of the factors tested were 0.000, which was less than the 0.05 requirement criteria for normality. Therefore, the retrieved data were non-parametric, allowing for the RII analysis to be conducted. From Table 6, global trends and industry standards was ranked first by the professionals from the survey as the key factor influencing the adoption and implementation of SCPs in Malawi, with an RII value of 0.779. This agrees with the findings of Olawumi and Chan [51] in that keeping abreast with global trends and complying with industry standards plays a significant role in driving the adoption of SCPs. This underscores Malawi's vision for 2063 to create an environmentally friendly and more resilient built environment, which is anchored to the global agenda for sustainable development. Social and health benefits was ranked second with an RII value of 0.762. This supports the findings of Tarker [78] in that social and health benefits are integral to SCPs as these practices focus on developing a healthy and inclusive physical environment that improves the well-being of current and future generations. Market demand and awareness was ranked third with an RII of 0.760, while access to green technologies and innovation was ranked fourth with an RII of 0.759. According to Saka et al. [46] increasing market demand for sustainable and resilient buildings, driven by environmental concerns, energy efficiency goals and the desire for healthier and more comfortable living spaces, significantly influences the adoption of SCPs.

Furthermore, supply chain considerations and education and training were ranked fifth and sixth with the same RII value of 0.758 but with different standard deviations of 0.765 and 0.830, respectively. Adequate education and training programs promote sustainable construction by equipping construction professionals with the knowledge and skills necessary to design, plan and execute sustainable building projects effectively [79]. Furthermore, sustainable projects prioritise suppliers that exhibit transparency in their sustainability performance, including disclosing their carbon footprint, waste management techniques and compliance with labour regulations.

The lowest ranked variable was company sustainability policy, with an RII value of 0.722. Despite the company sustainability policy not being ranked among the top factors, it still recorded a higher RII value, which suggests that it is equally significant in driving the adoption and implementation of SCPs in the Malawian construction industry. Inspecting Table 6 further, all of the variables under consideration had indices greater than 0.700, which indicates the importance of all of the factors in driving the adoption and implementation of SCPs [80]. Overall, these findings show that all 13 drivers examined were considered significant by the professionals in driving the adoption and implementation of sustainable construction practices in Malawi.

5. Conclusions

This study provides a comprehensive evaluation of sustainable construction practices within the Malawian construction industry. In achieving the aim of the study, an in-depth review of literature was carried out to identify the several sustainable construction practices and the factors influencing their adoption and implementation. These practices were based on the triple-bottom-line sustainability dimensions encompassing economic, social, and environmental.

Adopting a survey method, construction professionals were requested to evaluate these practices based on their level of adoption and implementation in construction projects. The findings revealed that economic and social practices such as efficient allocation of resources, use of quick construction tools, coordinated supply chains in the construction process, occupant health and safety quality performance, acoustic and visual quality performance of the building and the use of thermal insulations in buildings among others were identified as the most adopted and implemented sustainable practices for infrastructure projects in Malawi. However, environmental sustainability practices were rated very low, which suggests that fewer of these practices are implemented by professionals in infrastructure projects in Malawi. Therefore, there is a need to prioritise environmental sustainability practices to achieve a holistic sustainable construction industry. Overall, based on the weightings, it was deduced that the level of implementation of SCPs in Malawi is considered minimal compared to other developing countries.

Furthermore, the study suggests a comprehensive approach incorporating global trends and industry standards, access to green technologies and innovation, market forces, education and supportive legislation as crucial for increasing the level of adoption and implementation of SCPs in Malawi. The findings of this study provide policymakers and stakeholders with valuable insights on how to develop policy regulations that would improve the sustainability performance of infrastructure projects in Malawi, thereby contributing to sustainable development. Additionally, this study further provides a theoretical foundation for the adoption and implementation of sustainable construction practices in other developing countries, which would enhance the resilience and sustainability of infrastructure in these regions and contribute to achieving the global sustainable development agenda.

Regarding limitations, the study only focused on building infrastructure projects, which could affect the generalisability of the findings. Therefore, future studies may explore the adoption of sustainable construction practices in different infrastructure projects. Future investigations could also be conducted into why professionals focus more on economic and social sustainability practices when addressing sustainability issues in the construction industry.

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