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Article

Sustainable Construction Practices: Challenges of Implementation in Building Infrastructure Projects in Malawi

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Abstract: The implementation of sustainable construction practices (SCPs) has been identified as a significant approach to promoting and enhancing the sustainability performance of infrastructure projects globally. However, the adoption and implementation of SCPs in low-income countries like Malawi is still in its early stages and has faced several challenges. Therefore, this study aims to provide an empirical analysis of the challenges hindering the implementation of SCPs in building infrastructure projects in Malawi. The study employed a systematic review and a quantitative method with a questionnaire survey among 193 construction professionals within the Malawian construction industry. The data was analysed using descriptive statistics, One-Sample t-test and exploratory factor analysis. The results revealed that higher costs of sustainable building processes, lack of information on sustainable building products, and higher costs of sustainable building materials are the most critical challenges to the implementation of SCPs in Malawi. The factor analysis further revealed that institutional limitation was the most critical component, followed by inadequate technical experience, and the least critical component was financial. This study provides practical insights for policy reforms, robust regulatory frameworks, and well-equipped institutions with the necessary expertise to promote the widespread adoption and successful implementation of SCPs in the construction industry.

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1. Introduction

Sustainability has become a critical element in today's modern construction due to the need to minimise the adverse effects of construction activities on the environment, society and the economy. Sustainability in construction entails effectively managing structures, organisations, and resources to meet current and future demands while addressing the challenges that may arise in the short and long term [1]. A key area of concern when considering infrastructure sustainability in the construction industry is sustainable construction practices. According to Ainger and Fenner [2], sustainable construction practices encompass an integrated approach applicable to infrastructure planning and delivery to achieve a sustainable goal of establishing and maintaining a balance between the built and natural environments. For instance, environmentally sustainable construction practices, such as using waste reduction technologies in design and construction and using low carbon emission equipment in buildings, minimise construction waste generation and carbon emissions from buildings [3]. Similarly, incorporating energy-efficient design strategies reduces long-term energy costs [4]. According to Goh et al. [5] implementing social sustainability practices, such as promoting social inclusiveness in the construction sector, enhances project performance by improving worker productivity and promotes positive community interactions. Establishing a conducive and encouraging work environment and actively engaging with local communities and stakeholders is vital in ensuring the timely and cost-effective delivery of projects while meeting quality standards [6].

Furthermore, several countries have developed initiatives to encourage the adoption of sustainable practices in their construction industry. In 1990, the United Kingdom developed the Building Research Establishment Environmental Assessment Method (BREEAM). Since then, BREEAM has become the most extensively utilised criteria globally for evaluating and enhancing the environmental efficiency of buildings [7]. The Leadership in Energy and Environmental Design (LEED) Green Building Rating System was developed by the US Green Building Council to assess new and major renovations of institutional buildings, high-rise commercial buildings, and residential projects [8]. However, the indicators used by all of these building evaluation frameworks primarily emphasise environmental performance, particularly during the operation of the structure.

In Malawi, the government introduced the National Construction Industry Policy 2015 to ensure a transformed, sustainable and quality-driven construction industry. The policy outlined the general guidelines for implementing sustainable practices in infrastructure projects. However, this policy has not been adequately adopted and implemented due to a lack of awareness and knowledge, which impedes the successful completion of sustainable infrastructure projects [9]. This highlights a gap between the policy regulations and the successful implementation of sustainable construction practices (SCPs) in the Malawian construction industry.

Despite all the initiatives highlighted above to encourage and promote sustainable construction practices in infrastructure development, the adoption and implementation face challenges that hinder their widespread. A study by Aghimien et al. [10] compared the challenges of sustainable construction in South Africa and Nigeria and found the most significant challenges to be the high cost of investment and resistance to change by industry professionals. Also, a study by Khan et al.[11] identified the high initial cost of sustainable construction materials and lack of policy regulations as the most significant challenges faced in implementing sustainable procurement in Malaysia. Furthermore, Alsanad [12] discovered that a lack of awareness and government support are the most significant barriers to implementing green practices in Kuwait. Several other studies identified diverse challenges to the adoption of sustainable construction. Djokoto et al. [13] highlighted the inability of stakeholders to let go of traditional construction and project management practices as obstacles to sustainable construction. Pham et al. [14] confirmed that professionals in the construction industry in many developing countries are hesitant to go beyond clients' requirements, making the sector highly complex and challenging to adopt and implement sustainable practices. Based on the findings of Iqbal et al. [15], most clients are inclined to endorse sustainable construction practices only if they align with conventional construction methods. Also, the successful implementation of sustainable construction practices is frequently hampered by clients’ and key stakeholders' resistance to new and innovative construction approaches [16].

According to Dwaikat et al.[17] sustainable construction incurs additional costs ranging from 1% to 25% higher than conventional construction because of the complexity of the architectural layout and green practices. This makes SCPs very expensive to adopt and implement. Darko et al.[18] found that using sustainable building materials increases cost by 3-4% of the contract sum. However, introducing financial incentives such as subsidies and tax exemptions by various governments would promote and encourage the use of these materials. Similarly, the bureaucratic administrative processes involved in approving the use of cutting-edge technologies in building projects affect the implementation of SCPs. Other significant challenges include lack of appropriate building regulations, lack of awareness of sustainable practices, lack of information on sustainable building products and lack of stakeholder collaboration and communication [18–21].

However, most of these studies focused on high and middle-income countries. They utilised descriptive statistics approaches to rank these barriers, which creates the need for inferential statistical analysis to provide detailed insight and a better understanding of the challenges hindering

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the implementation of sustainable construction practices in building infrastructure projects in low-income countries like Malawi. Therefore, this study aims to provide an empirical analysis of the challenges hindering the implementation of sustainable construction practices in building infrastructure projects in Malawi. The study seeks to achieve this aim by identifying the critical challenges of sustainable construction practices in building infrastructure and mitigating strategies to enhance widespread adoption and implementation.

This study is essential to bridge this knowledge gap, mainly because a deeper understanding of the challenges affecting the implementation of SCPs is necessary to formulate successful strategies for enhancing sustainable practices in infrastructure projects. It is particularly crucial in low-income countries such as Malawi, where there have been few studies on sustainable construction [22]. This study contributes to the knowledge of sustainable construction by expanding the literature on the key challenges hindering the adoption and implementation of sustainable construction practices.

2. Research Methods

2.1. Research Design and Approach

This study employed a systematic review and a quantitative method with a questionnaire survey to identify the most critical and significant challenges of sustainable construction practices in the construction industry. These challenges were identified through a comprehensive review of pertinent literature. The review includes several literature sources related to the subject area obtained from academic databases such as Web of Science, Scopus, Google Scholar and Science Direct, which are considered to have broad coverage of journal articles, book chapters and conference papers [23]. Several studies were obtained from the search for inclusion in the review using keywords such as sustainable practices, sustainable construction, and barriers. The titles and abstracts of these studies were screened to exclude irrelevant materials. The full text of the screened studies was further examined to ensure compliance with the aim of this study. Twenty-five challenges were shortlisted, and these variables were coded into a questionnaire. A pilot survey was then conducted among five 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 [24]. Suggested corrections and recommendations from the pilot were reviewed and incorporated into the identified challenges as deemed appropriate in Table 1.

Table 1. Summary of challenges associated with the adoption and implementation of SCPs in infrastructure projects.

Code	Critical challenges	Reference
CH 1	Higher costs of sustainable building materials	[18,25]
CH 2	The technicalities of the construction process	[26,27]
CH 3	Lengthy bureaucratic procedures of sustainable building processes	[28]
CH 4	lack of knowledge about sustainable technology	[29–31]
CH 5	Lack of awareness of sustainable practices	[19,32,33]
CH 6	lack of information on sustainable building products	[34–36]
CH 7	Lack of stakeholder Collaboration	[37,38]
CH 8	Lack of Long-Term Performance Monitoring and Maintenance	[39]
CH 9	Poor communication between stakeholders	[20]

CH 10	Higher costs of sustainable building processes.	[17]
CH 11	Inadequate project planning and coordination	[21,40]
CH 12	Inability the inability of stakeholders to let go of traditional construction and project management practices	[41]
CH 13	Poor feasibility and management of risk	[42]
CH 14	Lack of sustainability building codes and policies	[36]
CH 15	Limited experience in selecting sustainable construction procedures and techniques	[43]
CH 16	Absence of sustainability criteria in the bidding process	[43]
CH 17	Inadequate funding for sustainable projects	[43]
CH 18	Lack of incentives for contractors who incorporate sustainability practices in the project delivery	[44]
CH 19	Inability the inability of contractors to budget sustainable projects	[27]
CH 20	Poor scope definition of sustainable construction requirements	[45]
CH 21	Incomplete sustainability specifications for projects	[46,47]
CH 22	Difficulty in complying with sustainable building codes and certifications	[46,48]
CH 23	Clients' unwillingness to pay extra for green buildings	[13,49]
CH 24	Fragmented guidelines for sustainable procurement procedure	[50]
CH 25	Need for special materials for sustainable projects	[51]

2.2. Population and Sampling

The population of a study comprises all the individuals or groups included in a research capable of providing feedback or being assessed to achieve the aim of a study. The study's population was determined to be 938, consisting of construction companies, real estate companies, consultants, and government agencies responsible for infrastructure development obtained from the National Construction Industry Council 2023 register. Using a stratified random sampling technique, the sample size was determined to be 273 across all groups within the Malawian construction industry. According to Singh et al.[52] stratified random sampling allows for the generalizability of the research findings.

2.3. Data Collection

The finalised questionnaire was administered to professionals within the Malawian construction industry through online and in-person. A total of 273 questionnaires were sent out to the respondents, and a total of 193 were retrieved, with valid responses obtained, resulting in a response rate of 71%. Liu et al. [53] opined that a response rate of approximately 30% is acceptable for academic research. Hence, a 71% response rate was considered acceptable. The questionnaire was divided into two parts. The first part asked about the characteristics of the sample. The second part requested respondents to evaluate the variables based on their knowledge and experience on the extent to which they agree

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with the variables as hindrances to the implementation of SCPs using a 5-point Likert scale with 5 = strongly agree, 4 = agree, 3 = undecided, 2 = disagree, and 1 = strongly disagree.

2.4. Method of Data Analysis

Using Statistical Packages for Social Sciences (SPSS) version 22 software, the data obtained was analysed using Cronbach's alpha, descriptive statistics, a One-Sample t-test and exploratory factor analysis. The one-sample t-test was adopted to examine the relationship between the variables and assess their significance to the Malawian construction industry. In assessing the variables, a mean threshold of 3.5 was set to obtain the most critical challenges relevant to the Malawian construction industry. The test examined whether the mean ratings of the identified challenges to the implementation of SCPs differed significantly from the hypothesised population mean of 3.5. Thus, when a mean score of any of the variables is greater than the sample mean (3.5), it indicates that respondents perceived such variables to be highly relevant and require more attention. Therefore, statistically examining the significance of each challenge against the threshold value would ensure that the challenges identified in this study are specifically applicable to the Malawian construction industry and similar contexts. A study by Lekan et al.[54] used a similar threshold to identify critical areas for improvement in quality management frameworks and their importance for industry advancement.

Additionally, exploratory factor analysis was used to examine the interrelationships among the variables [55]. There are two main approaches to factor analysis: exploratory factor analysis and confirmatory factor analysis. The exploratory factor analysis is utilised to extract information concerning the interrelationships among a set of variables. In contrast, confirmatory factor analysis is employed later in the research process, involving sophisticated and complex approaches used to test specific hypotheses concerning the structural relationships of variables. Factor analysis has been utilised in several studies in the construction sector. Ogunsanya et al.[56] employed factor analysis to determine the barriers to sustainable procurement in the Nigerian construction industry. Additionally, Darko et al.[57] used factor analysis to identify the underlying group barriers to the adoption of green technologies in the Ghanaian construction market.

Similarly, this study employed exploratory factor analysis to reduce or group the critical challenges affecting the implementation of SCPs in the Malawian construction industry. This was deemed necessary so that it can be easy to devise mitigation strategies for all. There are three steps in conducting exploratory factor analysis.

Firstly, assessing the suitability of the data set. The condition for the data suitability lies in the adequacy of the sample size and the strength of correlation among the variables. According to Watkins [58] a sample size of 150 or more is deemed appropriate for factor analysis. Also, on the strength of the interrelationships of the variables, the correlation matrix coefficient should be greater than 0.3. This is confirmed by the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity. Factor analysis is deemed appropriate when the Kaiser-Meyer-Olkin (KMO), which measures the sampling adequacy, is greater than the minimum limit of 0.5 and when the significant level of Bartlett's test of sphericity is 0.05 [59]. Additionally, Cronbach's alpha, which measures the reliability and the internal consistency of the instrument used to evaluate the variables, should be equal to or greater than 0.70 [60].

Secondly is factor extraction. To support the reliability of the results and interpretation, the average communality of the extracted variables should be greater than 0.60. Also, the communality values in the factor analysis suggest that a significant variable must produce eigenvalues greater than 0.50 at the initial iteration [55]. Lastly is the factor rotation, which provides a clearer picture of the extracted variables. SPSS provides the factors as clusters of variables, allowing the researcher to interpret these clusters. The varimax technique was utilised in this study. The findings and discussion are presented in the subsequent sections.

3. Results and Discussion

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3.1. Respondents' Demographic Information

Results of the background information of respondents obtained from the survey are presented in Table 2. Regarding the highest qualification, more than half of the respondents (76%), obtained a minimum of a bachelor's degree, while only 4% had secondary/senior high school qualifications. Concerning the profession, most participants were architects (24%), 22 % were project managers, 20% were civil engineers, 17% were quantity surveyors, and 3% were procurement officers, which suggests that most building infrastructure projects are carried out by professionals. In terms of experience, more than half of the respondents (62%) had more than 5 years of work experience. Moreover, 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. This indicates that participants had significant knowledge and experience required to offer valuable information for the study.

Table 2. Demographics of respondents.

Demographics of respondents	Responses per demographic (n=193)	Frequency (%)
Highest Qualification		
Secondary/Senior High	8	4
Diploma	46	24
Degree	105	54
Master's Degree	27	14
PhD	7	4
Job Description		
Architect	46	24
Project Manager	43	22
Civil Engineer	38	20
Quantity Surveyors	32	17
Specialist Engineer	18	9
Builder	9	5
Procurement officer	7	3
Work Experience		
1-5 years	74	38
6-10 years	68	35
11-15 years	42	22
16-20 years	7	4
21 years and above	2	1
Kind of Firm		
Construction Company	79	41
Consultant	55	28
Real Estate Company	31	16
Government Agency	28	15

3.2. One-Sample Test of the Challenges Affecting the Adoption and Implementation of SCPs.

The Cronbach's alpha was calculated to determine the internal consistency and reliability of the scale used to rate the various variables. The Cronbach's alpha value was 0.949, suggesting a high level of internal consistency across all the variables analysed and an excellent reliability of the scale used [61]. The one-sample test results are presented in Table 3. To obtain the most significant and critical challenges affecting the adoption and implementation of SCPs in Malawi, a test value of 3.5 was set, as used by Olanrewaju and Okorie [62] in assessing the significance of barriers to BIM implementation in Nigeria.

From Table 3, it can be inferred that the mean for all the variables under consideration was greater than 3.5, indicating a higher level of importance of all the variables as challenges hindering the adoption and implementation of SCPs to the Malawian constriction industry [63]. Higher costs of sustainable building processes was the first-ranked challenge hindering the adoption and implementation of SCPs in Malawi, with a MS value of 3.84, SD value of 0.750, t- value of 6.286, and p-value of 0.000< 0.05. According to Okoye et al. [64] sustainable construction involves higher expenses ranging from 1% to 25% compared to conventional construction due to the sophisticated architectural layouts and the implementation of green practices, which hinder the adoption of SCPs. The second-ranked challenge was the lack of information on sustainable building products (MS = 3.83, SD = 0.762, t = 6.002, p = 0.000 < 0.05). This affirms the findings of Koolwijk et al. [35] that the limited availability of sustainable building products compared to conventional materials in the local markets of developing countries makes it difficult for builders and developers to access information on these products for use. Higher costs of sustainable building materials was also ranked third (MS = 3.83, SD = 0.795, t = 5.749, p = 0.000 < 0.05). Jaffar et al.[65] consented that employing sustainable building materials during project execution is more expensive, leading to additional construction costs. This makes the use of these materials very difficult, considering the economic situation of most low-income countries like Malawi.

The fourth-ranked challenge was a lack of knowledge about sustainable technology (MS = 3.82, SD = 0.722, t = 6.233, p = 0.000 < 0.05). This alluded to Fathalizadeh et al. [66] view that many stakeholders in the construction sector, including engineers, architects, project managers and contractors, lack knowledge of the latest sustainable technologies available for use in building projects. This knowledge gap prevents them from incorporating innovative and eco-friendly solutions into their designs and construction processes. Coming fifth in rank was the inability of stakeholders to let go of traditional construction and project management practices (MS= 3.82, SD = 0.844, t = 5.247, p = 0.000 < 0.05). The reluctance of stakeholders to depart from traditional construction and project management practices poses a significant challenge to adopting and implementing SCPs in Malawi. Conventional construction practices often have deep-rooted cultural and institutional significance, making it difficult for stakeholders to embrace new construction approaches [67]. The need for special materials for sustainable projects (MS = 3.81, SD = 0.721, t = 5.937, p = 0.000 < 0.05) and lack of awareness of sustainable practices (MS = 3.81, SD = 0.814, t = 5.349, p = 0.000 < 0.05) were ranked sixth and seventh respectively. The absence of awareness may arise from multiple factors, such as limited exposure to sustainability concepts, inadequate training and education, and scarcity of easily accessible information and resources, thereby hindering SCPs adoption [19].

Furthermore, limited experience in selecting sustainable construction procedures and techniques (MS=3.80, SD = 0.752, t = 5.601, p = 0.000 < 0.05) was ranked eighth. Clients' unwillingness to pay extra for green buildings (MS = 3.79, SD = 0.763, t = 5.332, p = 0.000 < 0.05) and lengthy bureaucratic procedures of sustainable building processes with MS = 3.77, SD=0.750, t = 5.039, p = 0.000 < 0.05 were ranked ninth and tenth respectively. According to O'Dwyer et al [68], developing sustainable buildings can be excessively challenging due to the potential use of advanced technology and complex construction methods. Moreover, the administrative processes involved in approving the use of cutting-edge technologies in construction could lengthen project duration.

Similarly, the rest of the variables were ranked chronologically following the same approach, as indicated in Table 3. The least ranked variables in Table 3 were poor communication between stakeholders (MS = 3.66, SD = 0.808, t = 2.716, p = 0.007 < 0.05), inability of contractors to budget for sustainable projects (MS = 3.66, SD = 3.63, t = 2.223, p = 0.027 < 0.05), and poor scope definition of sustainable construction requirements with MS=3.62, SD = 0.782, t = 2.163, p = 0.032 < 0.05 as twenty-third, twenty-fourth and twenty-fifth respectively. Despite being ranked least, the mean scores (3.5) showed that these challenges were still perceived to be important in hindering the successful adoption and implementation of SCPs in Malawi [63].

Additionally, the findings showed that all the challenges were statistically significant among the respondents, as evidenced by the one-sample t-test results with the mean value of all the variables greater than 3.5 and p < 0.05. These challenges hindering the adoption and implementation of SCPs are many and need to be reduced or grouped for direct focus on how to mitigate them and enhance SCPs adoption and implementation in the construction industry. Therefore, factor analysis is employed to reduce the twenty-five challenges into five categories, allowing the industry to develop strategies to mitigate the challenges.

Table 3. One-Sample test of challenges affecting the adoption and implementation of sustainable construction practices.

				Test Value ($\mu = 3.5$)					
Code	Challenges	MS	SD	t-value	Df	Sig. (2-tailed)	MD	R	Significant (P<0.05)
CH1	Higher costs of sustainable building processes.	3.84	0.750	6.286	192	0.000	0.339	1	Yes
CH2	Lack of information on sustainable building products	3.83	0.762	6.002	192	0.000	0.329	2	Yes
CH3	Higher costs of sustainable building materials	3.83	0.795	5.749	192	0.000	0.329	3	Yes
CH4	Lack of knowledge about sustainable technology	3.82	0.722	6.233	192	0.000	0.324	4	Yes
CH5	Inability of stakeholders to let go of traditional construction and project management practices	3.82	0.844	5.247	192	0.000	0.319	5	Yes
CH6	Need for special materials for sustainable projects	3.81	0.721	5.937	192	0.000	0.308	6	Yes
CH7	Lack of awareness of sustainable practices	3.81	0.814	5.349	192	0.000	0.313	7	Yes
CH8	Limited experience in selecting sustainable construction procedures and techniques	3.80	0.752	5.601	192	0.000	0.303	8	Yes
CH9	Clients unwillingness to pay extra for green buildings	3.79	0.763	5.332	192	0.000	0.293	9	Yes
CH10	Lengthy bureaucratic	3.77	0.750	5.039	192	0.000	0.272	10	Yes

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	procedures of sustainable building processes								
CH11	Inadequate project planning and coordination	3.77	0.765	4.843	192	0.000	0.267	11	Yes
CH12	Fragmented guidelines for the sustainable procurement procedure	3.76	0.713	4.999	192	0.000	0.256	12	Yes
CH13	Lack of Stakeholder Collaboration	3.76	0.718	5.061	192	0.000	0.262	13	Yes
CH14	Lack of Long-Term Performance Monitoring and Maintenance	3.76	0.762	4.674	192	0.000	0.256	14	Yes
CH15	Inadequate Funding for sustainable projects	3.76	0.675	5.276	192	0.000	0.256	15	Yes
CH16	Lack of sustainable building codes and policies	3.76	0.828	4.305	192	0.000	0.256	16	Yes
CH17	Difficulty in complying with sustainable building codes and certifications	3.74	0.733	4.569	192	0.000	0.241	17	Yes
CH18	The technicalities of the construction process	3.74	0.826	4.051	192	0.000	0.241	18	Yes
CH19	Poor feasibility and management of risk	3.73	0.797	4.019	192	0.000	0.231	19	Yes
CH20	Absence of sustainability criteria in the bidding process	3.72	0.739	4.139	192	0.000	0.220	20	Yes
CH21	Lack of incentives for contractors who incorporate sustainability practices in the project delivery	3.72	0.753	4.062	192	0.000	0.220	21	Yes
CH22	Incomplete sustainability specifications for projects	3.66	0.755	2.908	192	0.004	0.158	22	Yes
CH23	Poor Communication	3.66	0.808	2.716	192	0.007	0.158	23	Yes

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	between stakeholders								
CH24	Inability of contractors to budget Sustainable projects	3.63	0.826	2.223	192	0.027	0.132	24	Yes
CH25	Poor scope definition of sustainable construction requirements	3.62	0.782	2.163	192	0.032	0.122	25	Yes

MS = mean score; SD = standard deviation; Df= Degree of freedom; MD = Mean Difference; Sig = Level of significance (95%); R = Ranking.

3.3. Exploratory Factor Analysis of the Challenges Affecting the Adoption and Implementation of SCPs.

Factor analysis is a statistical technique used to reduce a large number of measured variables to small components to enhance interpretability [69]. Twenty-five variables evaluating the challenges affecting the adoption and implementation of SCPs were subjected to principal factor (PC) analysis. Before the factor analysis, the suitability of the data was assessed. From Table 4, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was obtained to be 0.915, indicating a high confidence level. This suggests that the variables evaluated in this study have strong and significant correlations [59]. Also, Bartlett's Test of Sphericity was 3121.711 with a significant value of 0.000, confirming the adequacy of the sample used for the factor analysis.

From the results presented in Table 5, the average communality of the variables obtained after the extraction was 0.673, which is greater than 0.60, indicating that the extracted commonalities support the use of factor analysis for the variables [43]. Also, the rotated component matrix results shown in Table 6 resulted in a five-factor component solution. All the variables with factor loadings exceeding 0.300 were retained as they significantly contribute to interpreting the factor category. According to Tavakol and Wetzel [70] a factor loading greater than 0.300 or closer to 1 indicates that the variable strongly influences the component.

The five retained factors explained 67.265% of the total variance obtained, which is greater than the recommended 50% minimum value [71]. From Table 6, the first component explained 45.807% of the variance, the second component explained 6.575%, the third component was 5.675%, the fourth component was 4.705%, and the fifth component explained 4.503% of the variance. The remaining percentage (32.73%) explained the rest of the components, indicating that the five components can adequately represent the data [72]. Moreover, all the components had eigenvalues greater than 1, as shown in Figure 1.

The five components consisting of interrelated variables obtained from the factor analysis were assigned suitable aggregate names representing all the variables within each component, as shown in Table 6. Component 1 consisted of seven interconnected variables collectively named Institutional Limitations. The second component comprises six interrelated variables jointly called Inadequate Technical Experience. The third component had three variables identified collectively as Inadequate Knowledge and information. The fourth component consists of four variables named operational. The last component had five interrelated variables named financial.

Table 4. KMO, Bartlett's Test of Sphericity and Cronbach's Alpha.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.915
Bartlett's Test of Sphericity	Approx. Chi-Square	3121.711
	Df	300
	Sig.	0.000
Cronbach's Alpha	0.949	

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Table 5. Commonalities.

Code	Factors	Initial	Extraction
CH1	Higher costs of sustainable building processes.	1.000	0.552
CH2	Lack of information on sustainable building products	1.000	0.817
CH3	Higher costs of sustainable building materials	1.000	0.806
CH4	Lack of knowledge about sustainable technology	1.000	0.771
CH5	Inability of stakeholders to let go of traditional construction and project management practices	1.000	0.631
CH6	Need for special materials for sustainable projects	1.000	0.643
CH7	Lack of awareness of sustainable practices	1.000	0.802
CH8	Limited experience in selecting sustainable construction procedures and techniques	1.000	0.629
CH9	Clients unwillingness to pay extra for green buildings	1.000	0.600
CH10	Lengthy bureaucratic procedures of sustainable building processes	1.000	0.490
CH11	Inadequate project planning and coordination	1.000	0.647
CH12	Fragmented guidelines for the sustainable procurement procedure	1.000	0.662
CH13	Lack of Stakeholder Collaboration	1.000	0.687
CH14	Lack of Long-Term Performance Monitoring and Maintenance	1.000	0.618
CH15	Inadequate Funding for sustainable projects	1.000	0.621
CH16	Lack of sustainable building codes and policies	1.000	0.743
CH17	Difficulty in complying with sustainable building codes and certifications	1.000	0.666
CH18	The technicalities of the construction process	1.000	0.742
CH19	Poor feasibility and management of risk	1.000	0.665
CH20	Absence of sustainability criteria in the bidding process	1.000	0.572
CH21	Lack of incentives for contractors who incorporate sustainability practices in the project delivery	1.000	0.694
CH22	Incomplete sustainability specifications for projects	1.000	0.704
CH23	Poor Communication between stakeholders	1.000	0.585
CH24	Inability of contractors to budget Sustainable projects	1.000	0.702
CH25	Poor scope definition of sustainable construction requirements	1.000	0.767

Extraction Method: Principal Component Analysis.

Table 6. Rotated Component Matrix.

		Component					% of Variance
		1	2	3	4	5	
	Institutional Limitations						45.807
CH16	Lack of sustainable building codes and policies	0.759					
CH19	Poor feasibility and management of risk	0.703					
CH5	Inability of stakeholders to let go of traditional construction and project management practices	0.684					
CH6	Need for special materials for sustainable projects	0.546					

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CH11	Inadequate project planning and coordination	0.535					
CH12	Fragmented guidelines for the sustainable procurement procedure	0.501					
CH20	Absence of sustainability criteria in the bidding process	0.472					
	Inadequate Technical Experience						6.575
CH25	Poor scope definition of sustainable construction requirements		0.804				
CH24	Inability of contractors to budget Sustainable projects		0.764				
CH22	Incomplete sustainability specifications for projects		0.691				
CH17	Difficulty in complying with sustainable building codes and certifications		0.658				
CH8	Limited experience in selecting sustainable construction procedures and techniques		0.648				
CH18	The technicalities of the construction process		0.563				
	Inadequate Knowledge and information						5.675
CH7	Lack of awareness of sustainable practices			0.807			
CH4	Lack of knowledge about sustainable technology			0.772			
CH2	Lack of information on sustainable building products			0.771			
	Operational						4.705
CH14	Lack of Long-Term Performance Monitoring and Maintenance				0.673		
CH13	Lack of Stakeholder Collaboration				0.665		
CH10	Lengthy bureaucratic procedures of sustainable building processes				0.639		
CH23	Poor Communication between stakeholders				0.580		
	Financial						4.503
CH9	Clients' unwillingness to pay extra for green buildings					0.852	
CH1	Higher costs of sustainable building processes.					0.841	
CH3	Higher costs of sustainable building materials					0.776	
CH15	Inadequate Funding for sustainable projects					0.582	
CH21	Lack of incentives for contractors who incorporate sustainability practices in the project delivery					0.522	

Extraction Method: Principal Component Analysis; Rotation converged in 11 iterations.

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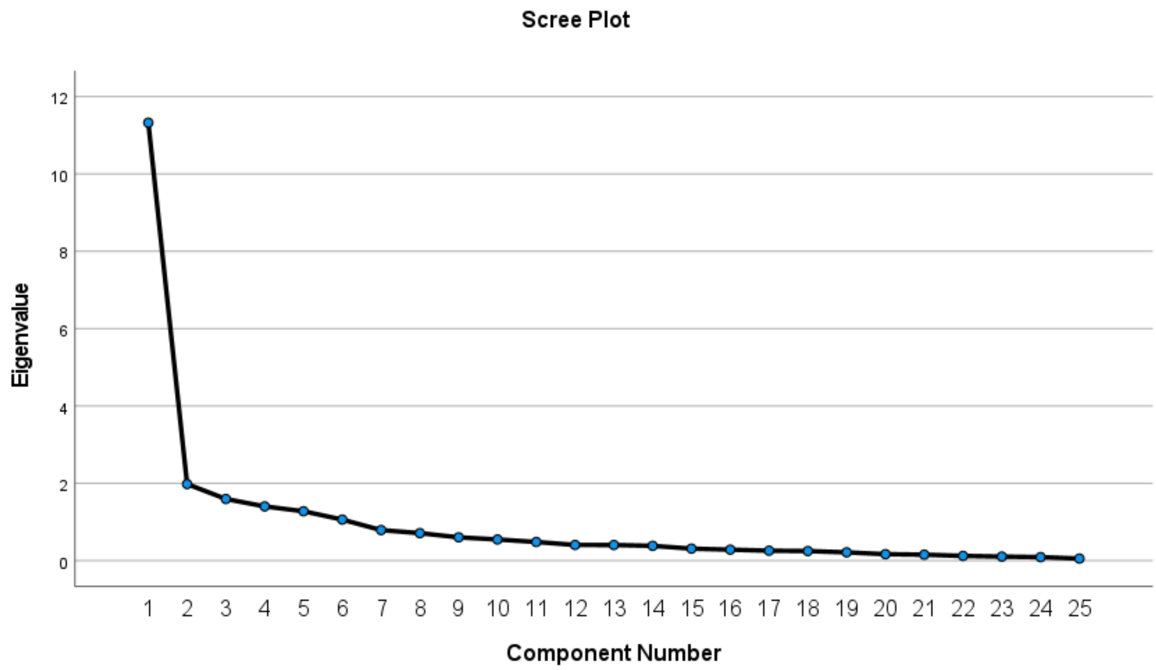

Figure 1. Scree plot.

Component I: Institutional Limitations

The seven challenges extracted for component 1 were lack of sustainable building codes and policies with factor loading of 0.759, poor feasibility and management of risk (0.703), inability of stakeholders to let go of traditional construction and project management practices (0.684), need for special materials for sustainable projects (0.546), inadequate project planning and coordination (0.535), fragmented guidelines for the sustainable procurement procedure(0.501), and absence of sustainability criteria in the bidding process (0.472). These challenges collectively explain the challenges associated with institutional capacity and coordination, emphasising the need for policy reforms and streamlined processes necessary for adopting and implementing sustainable construction practices in infrastructure projects. The findings agree with the findings of Adabre et al. [73], which highlighted that institutional challenges significantly affect the delivery of sustainable housing in developing countries. The findings suggest the need for the Malawian government and the National Construction Industry Council to develop clear and comprehensive sustainable building codes for the Malawian construction industry, which align with global best practices to increase SCPs adoption and implementation. Also, the government should establish a monitoring and evaluation framework and engage stakeholders in the policy-making process to increase the capacity of institutions to promote SCPs adoption and implementation in the construction industry. Oke et al.[74] opined that the adoption and implementation of SCPs depend on the efforts of the government and institutions responsible for policy regulations and coordination of construction activities. Therefore, addressing the above-mentioned institutional challenges would promote the widespread adoption and implementation of SCPs in the Malawian construction industry.

Component 2: Inadequate Technical Experience

Six challenges were extracted for this component, which includes poor scope definition of sustainable construction requirements (0.804), the inability of contractors to budget sustainable projects (0.764), incomplete sustainability specifications for projects (0.691), difficulty in complying with sustainable building codes and certifications (0.658), limited experience in selecting sustainable construction procedures and techniques (0.648) and the technicalities of the construction process (0.563). This group explains the challenges associated with inadequate technical experience in

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delivering sustainable projects. This confirms the findings of Ahmed & El-Sayegh [43] which highlighted that a workforce with inadequate technical experience and expertise in handling sustainable construction processes makes it difficult to adopt and implement SCPs in infrastructure project delivery. In Malawi, where the adoption and implementation of SCPs are still minimal, government and industry stakeholders need to organise periodic training sessions on sustainable construction practices for project teams to ensure these practices are integrated into project delivery [9]. Also, rating systems and certifications should be developed to provide clear criteria and guidelines for evaluating the sustainable performance of buildings [75]. Furthermore, there should be proper frameworks and well-defined sustainability guidelines for every project to enable contractors and consultants within the industry to deliver sustainable projects effectively [76].

Component 3: Inadequate Knowledge and Information

This component consists of three critical challenges, including lack of awareness of sustainable practices (0.807), lack of knowledge about sustainable technology (0.772) and lack of information on sustainable building products (0.771). This cluster emphasised the knowledge and information gaps as critical challenges to implementing SCPs. The lack of awareness of sustainable practices (0.807) emerges as the most significant barrier, followed by a lack of knowledge about sustainable technology (0.772), indicating limited stakeholders' understanding of sustainable construction practices within the Malawian construction industry[77]. This could be attributed to inadequate research and development in sustainable construction. Similarly, the lack of information on sustainable building products (0.771) highlights the absence of a comprehensive national construction database or information systems to provide accurate, accessible and reliable information on sustainable construction practices. Marchi et al. [78] proposed providing education and training for industry professionals and implementing regulatory policies and frameworks. Also, improving information systems to provide access to reliable information for construction firms and government departments can significantly advance the adoption and implementation of sustainable practices in the construction sector.

Component 4: Operational

For component 4, four challenges were extracted, which include lack of long-term performance monitoring and maintenance (0.673), lack of stakeholder collaboration (0.665), lengthy bureaucratic procedures of sustainable building processes (0.639) and poor communication between stakeholders (0.580). This collectively explains the operational challenges that hinder the smooth implementation of sustainable construction practices. This agrees with the findings of Adhi & Muslim [79] that the use of sustainable approaches during construction is often faced with a lack of cooperation among stakeholders and lack of administrative support, resulting in fragmented efforts and inefficiencies in the execution of sustainable projects. The findings suggest the need for improved operational frameworks and systems to foster stakeholder collaboration, streamline processes and enhance communication to ensure timely and effective execution of sustainable projects [80]. Furthermore, government and construction professional organisations should implement a system to monitor the sustainable performance of infrastructure projects regularly.

Component 5: Financial

This underlying component comprised five critical challenges, which are clients' unwillingness to pay extra for green buildings (0.852), higher costs of sustainable building processes (0.841), higher costs of sustainable building materials (0.776), inadequate funding for sustainable projects (0.582), lack of incentives for contractors who incorporate sustainability practices in the project delivery (0.522). This component explained the financial challenges faced in adopting and implementing sustainable construction practices while delivering infrastructure projects. According to Malik et al. [81] the construction industry has faced several challenges, including limited access to financial resources, which affect the sustainable delivery of infrastructure projects. The cost of adopting and implementing SCPs is not only a significant challenge in Malawi but also in other developing and developed countries [72]. The findings confirm that of Ahmed and El-Sayegh [43] who opined that financial issues are the most significant barriers to sustainable construction in the United Arab Emirates. Liu et al.[82] proposed making sustainable construction materials economically viable and affordable and improving upon traditional project management practices would promote the widespread adoption of sustainable construction practices in infrastructure projects. According to [83], providing financial mechanisms and incentives to contractors would help alleviate the higher upfront costs associated with sustainable building projects.

4. Conclusions

The study provided an overview of the concept of sustainable construction practices and their implementation in developing countries. The study further provided an empirical analysis of the challenges hindering the implementation of sustainable construction practices in building infrastructure projects in Malawi. In achieving the aim of the study, 25 challenges were identified through a comprehensive review of pertinent literature.

A survey was conducted among 193 construction professionals in the Malawian construction industry to assess the criticality of the identified challenges in the context of Malawi. The data was analysed using descriptive statistics, One-Sample t-test and exploratory factor analysis.

The results after the analysis revealed that all the 25 challenges were critical and significant to the adoption and implementation of SCPs in the Malawian construction industry. The most critical challenges were higher costs of sustainable building processes, lack of information on sustainable building products and higher costs of sustainable building materials. This suggests the need for the government to prioritise providing financial mechanisms and incentives to contractors who incorporate sustainable practices during project execution to encourage the adoption and implementation of SCPs in the construction industry. Additionally, establishing a national construction database to provide access to reliable information on sustainable practices and conducting awareness campaigns would significantly enhance the adoption and implementation of SCPs in the construction industry.

Furthermore, the results from the factor analysis identified five components: Institutional limitations, Inadequate technical experience, Inadequate knowledge and information, and Operational and Financial challenges. The results also indicated that institutional limitation was the most critical and dominant of the five components, followed by inadequate technical experience, and the last component was financial. This suggests a need for policy reforms and capacity building of industry professionals to develop supportive regulatory frameworks and equip institutions with the necessary expertise to promote the adoption and successful implementation of sustainable construction practices in Malawi. Additionally, government and professional bodies should provide training programs tailored to SCPs to enhance professional skills and bridge the knowledge gap among industry professionals. This would allow policymakers and industry stakeholders to develop effective strategies to promote the widespread adoption and successful implementation of SCPs in the construction industry. Moreover, the findings of this study not only contribute to filling the knowledge gap concerning sustainable construction practices challenges in low-income countries but also provide useful information to advocates and international organisations interested in promoting SCPs in Malawi to ultimately achieve a more resilient and sustainable infrastructure development.

Despite achieving the aim of the study, the study still faced some limitations. The study focused on building infrastructure and the sample size was relatively small, which could affect the generalisability of the findings. Future studies can be done with a larger sample size and in different infrastructure projects. Moreover, future studies could analyse the difference between the SCPs implementation challenges in Malawi and many developed countries.

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