



Understanding the fundamental barriers to environmental management system implementation in developing countries

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Received: July 04, 2024 **Accepted:** August 22, 2024 **Published:** October 24, 2024

Cite this article: Ojo LD, Oladinrin OT, Chan APC, Owusu EK. Understanding the fundamental barriers to environmental management system implementation in developing countries. J Build Des Environ. 2024;2:36971. <https://doi.org/10.70401/jbde.2024.0003>

Abstract

Construction organizations in developing nations constantly lag in embracing changes in innovation, environmental sustainability, and safety, amongst others. Their contributions to environmental degradation, resulting in health-related consequences for construction stakeholders, are also alarming. Implementing environmental management tools such as environmental management systems (EMS) is often advocated to address the negative environmental impacts of construction organizations. Construction firms in developed nations have embraced EMS and implemented it to enhance construction business, environmental performance, and construction workers' health, while similar evidence is not recorded in developing nations. Therefore, this study investigated the barriers to EMS implementation through a survey of construction professionals in the Nigerian construction industry. 106 valid data were analyzed using factor analysis, Cronbach's alpha test, and fuzzy synthetic evaluation (FSE). The results of the factor analysis revealed four groups of barriers to EMS implementation, which are prioritized in the order of knowledge-related, stakeholders-related, process-related, and cultural-related barriers with FSE. The relationships between the four classes of barriers were determined using interpretive structural modelling (ISM) in which "knowledge-related barriers" are indicated as the core barrier to EMS implementation. To address the barriers to EMS implementation, organizing training, providing the needed resources for environmental education, collaborating with construction stakeholders, providing a reward system, and others were recommended. This study contributes theoretically and practically to environmental-related discourses in the construction industry. Theoretically, utilizing FSE provides an interesting insight that acknowledges the unique challenges of developing nations in the domain. Practically, this study gives an actionable focus for construction stakeholders to domesticate EMS within the local construction environment, thereby improving knowledge of the importance of environmental sustainability and pro-environmental behaviors.

Keywords: Barriers, construction industry, developing nations, environmental management system, interpretive structural modeling, sustainability

1. Introduction

All industries contribute to the deplorable environmental state of any given nation^[1-2] however, the construction industry has the lion's share in the environmental menace^[3-5]. The construction industry accounts for significant material waste, about 40% of material and energy use, 80% of air pollution, noise pollution, and 40% of water pollution^[6,7]. These various environmental contaminants generated via construction activities threaten the ecosystem, construction workers, stakeholders, and society^[8,9]. Therefore, managing environmental pollutants becomes imperative for the sustenance of the ecosystem, the safety of humans, the reduction of waste, and the judicious utilization of limited construction resources. Addressing the construction industry's environmental management patterns and practices is also important because of its central role in transforming various materials into built assets^[10]. Although the positive impact of the industry on economic growth is indispensable^[11], the environmental squalor of the industry is also alarming^[12], especially in developing nations.

In developed nations, environmental-mindedness has fuelled the implementation of environmental management tools such as environmental management systems (EMS) to manage the environmental impact of construction firms^[13,14]. The goal of EMS



implementation, which is to continually enhance organizational practice for delivering free pollution services in compliance with pro-environmental legislation^[15], also aids the actualization of sustainable development goals^[16]. Although the construction sector of developed nations such as Australia, Germany, the USA, and others have promulgated and adopted EMS tools^[17,18], developing nations are yet to play a significant active role in environmental management practices. Interestingly, most of the world's nations which are still developing states, are backwards in embracing environmental sustainability. Understandably, industrialization and economic development may be prioritized in developing nations, which could contribute to poor environmental conditions; however, pragmatic and complementary environmental management efforts are essential. Although Sakr *et al.*^[19] opined that the EMS implementation is gaining momentum in construction firms of developing nations, some barriers still hinder comprehensive EMS implementation.

It is also important to note that the lack of EMS implementation in developing countries can continually contribute to environmental degradation, which arises from urbanization and industrialization^[20]. Recalling that the urban population is estimated to increase to 70% by 2050^[21], ensuring environmental management strategies while meeting both present and perhaps future infrastructure needs is essential. The balance between environmental protection and economic growth is also a notable problem in which developing nations appear to embrace economic growth without proper consideration of the environmental impact^[22]. In addition, the global call for environmental consciousness is not receiving laudable attention in developing nations. Therefore, investigating the barriers to EMS implementation is deemed important.

Past studies have investigated the driver^[23,24], benefits^[25,26], and barriers^[27,28] of EMS implementation. The non-implementation of EMS in construction organizations in developing countries is obvious and still needs to be addressed^[27]. The study by Ojo *et al.*^[28] identified some barriers to EMS in the Nigerian construction industry and grouped them into three. Meanwhile, some key barriers were intentionally omitted in the classifications based on a chosen metric in their analysis. Therefore, re-classification is vital for a comprehensive overview of the barriers. Owolana and Booth^[27] used a limited sample size, which may be insufficient to generalize the findings. Besides, some barriers to EMS implementation were not included in the investigation of Owolana and Booth^[27]. Hence, it is important to further investigate the barriers to EMS implementation in the construction industry. Prioritizing the barriers is also essential to providing practical recommendations for relevant stakeholders in the industry. Moreover, the fundamentals of the barriers can be well understood for prompt action in the industry. Through the findings of this study, stakeholders in the construction industry of developing nations can be well informed on the proactive steps to tackle the barriers to EMS implementation.

To effectively address the fundamental barriers hindering the implementation of EMS in the construction industry of developing countries, this study is designed with specific objectives. Initially, it aims to assess the various obstacles that impede EMS adoption within the sector. Following this assessment, the study will categorize these barriers, helping to organize them into coherent groups for better analysis. Subsequently, these categorized barriers will be prioritized to identify which obstacles are most significant and require immediate attention. Finally, the study seeks to determine the interrelationships between these groups of barriers, providing insights into how different challenges may influence one another and impact the overall feasibility of EMS implementation in the construction industry.

By realizing the aforementioned objectives, this study is intended to significantly enhance the theoretical and practical understanding of EMS implementation within the construction industry of developing nations. Theoretically, it addresses gaps in the existing literature by providing a structured classification of barriers that were previously overlooked or inadequately explored due to methodological limitations such as small sample sizes or selective metrics. By offering a more comprehensive and detailed framework, this study is intended to deepen the readers' understanding of the specific challenges faced in the implementation of sustainable practices across varying economic contexts, thereby enriching the global discourse on environmental management.

Practically, this research provides stakeholders in the construction industry—ranging from policymakers to company executives and environmental managers—with essential insights for effectively addressing the barriers to EMS implementation. By identifying and prioritizing the most pressing barriers and clarifying their interdependencies, the study lays out a strategic pathway for targeted interventions. This guidance is particularly valuable in developing countries, where it supports efforts to balance industrial growth with environmental sustainability, thereby contributing to the achievement of global sustainability goals.

2. Literature Review

2.1 Environmental management system

Environmental management principles originated from the first United Nations (UN) conference on the Human Environment^[29,30]. The conference led to the establishment of the World Commission on Environment and Development, various environmental ministries, parastatals, and commissions in developed nations^[31]. Since then, developed countries have been actively involved in environmental sustainability and the provision of funds to further investigate ways of enhancing environmental performance. Hence, environmental consciousness, sustainable development, and production rapidly permeate their various sectors. Although the environmental performance in developed nations can be linked to the pollution haven hypothesis, which may leave developing nations in a

deplorable environmental state^[32], the proactiveness of developed countries to environmental management issues cannot be undermined^[33].

The bedrock of EMS, which depicts responsible and accountable enterprises' actions towards the environment and business operations' improvement simultaneously^[34,35] has been gaining wide attention. The required responsiveness and responsibility of organizations to the ecosystem have sparked scholarly debates between scholars and practitioners for decades^[36,37]. As the tides of the event have always been, countries with sensitive and actionable stances promulgated policy and enforcement strategies to ensure the commitment of organizations to environmental consciousness. Some stakeholders also ensured that their organizations implemented environmental management strategies for business practices in consonance with government requirements^[13]. Thus, organizations are forced to embrace environmental management tools such as EMS to enhance ecological resilience and economic viability. Although it is often believed that large-sized organizations are often proactive in implementing EMS^[38], the knowledge and awareness of EMS in other smaller organizations in developed nations cannot be compared with that of developing economies.

According to Lo-Iacono-Ferraira *et al.*^[39], EMS is described as a systematic process for an organization's environmental impact management towards attaining sustainable practices. The coordinative framework of EMS can assist organizations in complying with environmental regulations. The advocacy for EMS implementation often hinges on ethical, commercial, legal, and economic reasons^[40,41] and also assists organizations to see from the environmentalist lens. As the movement for environmental consciousness gains more attention, leading to training, internal environmental audits and reviews, and so on^[42], there is a paucity of similar records in some developing nations because of some barriers. Therefore, identifying the barriers to EMS may be essential for categorization and prioritization for stakeholders to take action.

2.2 Barriers to environmental management system

The barriers to EMS implementation in any organization or domain could be detrimental to achieving environmental performance. The barriers include the high cost required to implement EMS which has been indicated in various past studies^[16,43,44]. The financial requirement for EMS implementation covers the cost of certification and assessment, purchase of materials and technology, maintenance, engaging expert consultants, human resources, and so on^[23,45]. Although the initial capital outlay of EMS implementation may be high, the resultant effect of its implementation, such as pollution reduction, waste minimization, and enhanced productivity points at reduced lifecycle cost^[28]. According to the research of Kola-Lawal *et al.*^[23], the high cost of EMS implementation is regarded as a critical barrier militating pro-environmental behavior, which also scares organizations. Organizations with forthright impetus to embrace pro-environmental initiatives may also be faced with resistance to change from the employees, who are indispensable in achieving the organization's environmental objectives^[46]. On the other hand, an organization may be responsible for the resistance to change^[47]. In the study Owolana and Booth^[27], employee resistance to change is more prevalent, which depicts the poor attitude of the construction professionals to environmental management initiatives.

Top management may determine flagrant resistance or acceptance of EMS implementation^[28]. Provision and approval of facilities for training and education for EMS implementation by top management officers can effectively help achieve pro-environmental goals at all levels of the organization. However, a lack of top management support would not only hinder EMS implementation but discourage subordinates' environmental consciousness and further worsen the environmental performance of the organization^[48]. From a broader perspective, a lack of government support is also a grave barrier to EMS implementation^[27]. The poor and ineffective response of the governments in many nations to environmental hazard contributions from various sectors can fuel the unwillingness to implement EMS. Logically, the lack of government support can also sustain other barriers to EMS implementation, such as difficulty in dealing with environmental issues^[28], possibly because of the government's influential capacity to coordinate various sectors, stakeholders, and international organizations to overcome any issues in the construction industry.

Furthermore, the ambiguity in interpreting EMS has also been indicated as a potential barrier to EMS implementation^[43], which requires precision in interpretation for all categories of stakeholders^[48]. According to the research of Zutshi and Sohal^[49], the ambiguous scope of EMS is a major drawback that hinders many organizations from the initiative. Johnstone^[50] also corroborates the ambiguity of interpreting the EMS and how best to go about the implementation, especially in SMEs. Therefore, it can be inferred that the dearth of specialists in environmental-related issues can contribute to the ambiguity in the interpretation of EMS. In present decades of innovation and internet connectivity, it is believed that the presence of specialists may outweighs instruction manual or procedural processes to a large extent^[51]. Interestingly, it has also been indicated in past studies that a lack of specialists is a significant barrier to EMS implementation in the construction industry of developing countries^[27,52]. The low awareness of EMS is also reported in construction organizations^[53], even among influential construction project contractors in developing nations^[19]. The low awareness of EMS may be hinged on other barriers, such as a lack of knowledge of certifier systems, which has been reported in the construction industry of Singapore, China, Slovenia, and Egypt^[19,54,55] or lack of training and education about EMS^[27,28]. Interestingly, the pressure and persistent demand for environmentally sustainable practices from stakeholders led to EMS implementation in some developed nations^[13]. Thus, limited pressure from stakeholders or perhaps lack of pressure from relevant stakeholders in developing countries may be regarded as a barrier to EMS implementation.

Many of the barriers to EMS are linked to inadequate or lack of training and education^[28,53] because of its essentiality in implementing a new system in a business environment^[24]. The knowledge required for employees, employers, and stakeholders to cultivate environmental management initiatives can be acquired through training and education^[27]. An environmental-compliant establishment can be a product of knowledge received via seminars, conferences, practicum, or symposiums from experts in the domain. Although reimbursement for training and education fees to employees in construction organizations in developing nations may be uncommon^[27], top officials in construction companies can support the training of key staff who in turn would pass the knowledge to in-house members of the companies. Furthermore, the poor environmental culture in the construction industry has been reported to be a barrier to EMS implementation^[56]. Non-consideration of environmental impacts due to the weak environmental culture of construction activities also hinders innovation among construction stakeholders. Therefore, Ojo *et al.*^[28] advocated for an environmental-friendly philosophy among construction stakeholders to realize the advantages.

The high disintegration of the construction process can also account for the barriers to EMS implementation. Therefore, developed nations such as Sweden have actively ensured that environmental impacts are taken into consideration in all construction processes^[6]. The involvement of multi-disciplinary professionals and stakeholders in different phases of construction projects may also contribute to the barrier^[57]. Besides, it may be difficult to pinpoint the stakeholder with the most resultant negative impacts and contributions to poor environmental performance. The lack of leading initiatives in multi-national companies can also militate EMS implementation in a given country or sector^[9]. More importantly, communicating environmental initiatives from leading construction companies to other followers may be advantageous to permeate an industry with the knowledge of EMS benefits^[9,58]. The barrier of complex documentation process noted with EMS implementation^[53,59] may also be minimized through the involvement of leading organizations in the same environmental goals. In fact, leading international organizations can provide the knowledge transfer for SMEs to be part of an environment-friendly move. A summary of the barriers to EMS implementation obtained from extant literature is captured in [Table 1](#).

Table 1. Summary of barriers to environmental management system implementation.

Barriers	1 ^[43]	2 ^[16]	3 ^[23]	4 ^[27]	5 ^[19]	6 ^[9]	7 ^[49]	8 ^[48]	9 ^[50]	10 ^[53]	11 ^[6]	12 ^[44]	13 ^[56]	14 ^[77]	15 ^[78]	16 ^[38]
BR1-High costs of EMS implementation.	√	√	√	√	√	√	√		√	√		√	√	√		√
BR2-Organization resistance to change.		√	√	√	√		√							√		
BR3-Difficult in dealing with environmental issues.		√					√			√				√		
BR4-Ambiguity in interpretations of EMS.		√					√	√	√							√
BR5-Multi-layered sub-contracting bottleneck.		√		√			√			√						
BR6-Low awareness of EMS.	√		√		√				√		√	√		√		
BR7-Unclear guidelines for EMS implementation.		√										√				
BR8-Lack of leading initiative among construction companies.		√			√	√	√									
BR9-High disintegration of construction process.					√						√					
BR10-Time consuming for improving environmental performance.		√		√			√		√	√				√	√	
BR11-Lack of specialists in environmental issues.		√	√		√	√							√	√	√	
BR12-Lack of top management support.		√	√	√	√							√	√	√		
BR13-Limited pressure from stakeholders.	√	√		√		√		√								√
BR14-Complex documentation process.			√	√			√		√	√						
BR15-Lack of training and education about EMS.	√	√		√	√				√	√						

BR16-Weak environmental management culture.	✓	✓		✓	✓	✓	✓	✓	✓
BR17-Negative attitudes of employees.	✓	✓	✓		✓				
BR18-Lack of knowledge of certifier systems.	✓			✓	✓	✓		✓	✓
BR19-Lack of environmentally friendly technologies and materials.	✓	✓	✓		✓			✓	
BR20-Lack of government/ legislative support.	✓		✓	✓	✓		✓	✓	✓

EMS: environment management system.

3. Methodology

3.1 Research design

This study investigates the barriers to EMS implementation for prioritization and identifies their interrelationships accordingly. To achieve this, a survey research design was adopted to garner quantitative data through a questionnaire. A survey research design was used in this study because of its notable advantage of obtaining large responses from the target sample within a considerable period^[62]. On the other hand, survey research design also aligns with polyadic theory, in which responses on a domain of investigation can be obtained from various professions, groups, and organizations^[33,63]. Therefore, the designed survey of this study was administered to construction professionals in the Nigerian construction industry to elicit their opinions on the barriers to EMS implementation.

3.2 Sampling

The target construction professionals in the study were architects, builders, engineers, project managers, and quantity surveyors in Lagos State, Nigeria. These professionals have requisite roles, competence, and skills in sustainable development and environmental management in the construction industry^[64]. Lagos State was also chosen because of its uniqueness as the economic centre of construction activities and the seat of many construction head offices and construction professionals in Nigeria^[65], and convenient sampling was adopted to administer the questionnaire to the target respondents. The respondents employed to assess the relationships between the barriers after conducting some fundamental analyses were purposely selected. The flowchart of the research methodology for the study is presented in [Figure 1](#).

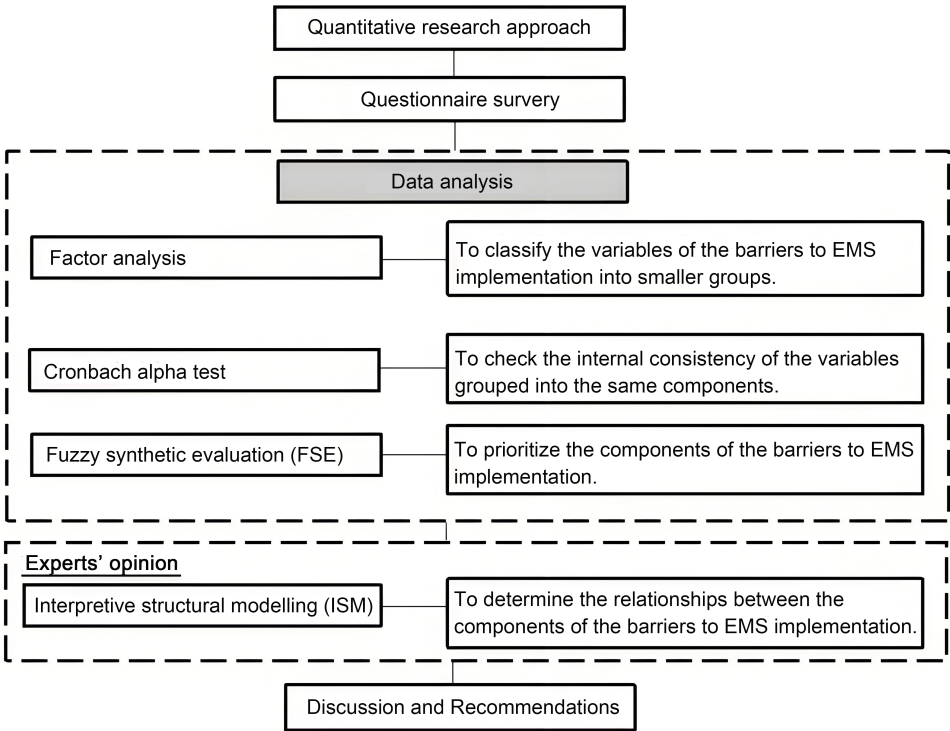


Figure 1. Flowchart of research methodology. EMS: environment management system.

3.3 Questionnaire development and data collection

The development of a questionnaire kick-off with an extensive literature review to identify barriers to EMS implementation in the construction industry. The outcome of the literature review led to the identification of twenty barriers to EMS implementation used to elicit the opinions of construction professionals in this study. The questionnaire comprised two sections: 1) background information such as profession, size of the employee in the organization, type of organization, year of experience, and so on, and 2) the twenty barriers to EMS implementation. The questions on the barriers were asked on a 7-point Likert scale in which 1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree or disagree, 5 = somewhat agree, 6 = agree, and 7 = strongly agree^[66]. The 7-point Likert scale was chosen in this study because of its detailed granularity compared to a lesser-range Likert scale^[67]. The respondents were assured anonymity and confidentiality of the data provided in the survey to minimize any potential bias in self-reporting.

A total of 205 copies of the questionnaire were successfully administered, while 110 copies were retrieved. A careful investigation of the returned data led to the discovery of 4 questionnaires that were not fit for analysis, therefore, they were discarded, leaving us with 106 copies of the questionnaire. Of the respondents, 61.1 quantity surveyors, 11.6% were engineers, 15.8% were architects, 7.4% were project managers, and 4.2% were builders. The majority of the respondents worked in quantity surveying firms (42.1%); others were working for client organizations (8.4%), contracting organizations (10.5%), architectural firms (13.7%), and engineering consulting firms (25.3%). Over 50% of them had more than five years of work experience in the construction industry as division head of a department in the organization (3.2%), technical staff (20%), professional staff (75.8%), and clerical staff (1.1%). A total of 4.2% had doctorate degrees, master's degrees (16.8%), 67.4% (bachelor's degree), and 11.6% had diploma certificates.

3.4 Methods of data analysis

The 106 valid data received were analyzed with both descriptive and inferential statistics. The background information of the respondents was analyzed using frequency and percentage. The 20 barriers to EMS implementation were categorized using factor analysis with a minimum factor loading of 0.3 ensured since the sample-to-item ratio was considered satisfactory^[28]. The internal consistency of the variables grouped into each principal component was checked with Cronbach's alpha. Based on the results of the factor analysis, the components generated were prioritized using soft computing techniques called fuzzy synthetic evaluation (FSE) to draw necessary conclusions in the study. The relationships between the groups of the barrier were determined using the interpretive structural modelling (ISM) approach with the opinions of five experts in environmental management. The five experts comprised three academics, one environmental management advocate group leader, and a construction professional with background knowledge in environmental studies and published articles in refereed journals.

4. Results

4.1 Categorization of EMS barriers

The barriers to EMS implementation in this study were factor analyzed using varimax rotation (eigenvalue-1 cut-off), which is essential to determine principal components of elements in a factor group^[68]. The sampling adequacy of the dataset was checked using Kaiser-Meyer-Olkin, and a value of 0.853 was obtained at a significant level of 0.000. Table 2 shows the results of the factor analysis of the barriers to EMS implementation. Of all the factor loading, 'lack of government/legislative support (BR20)' has an unacceptable value below the minimum threshold of 0.3. Therefore, it was deleted. Based on past studies, the variables with unsatisfactory factor loading can be deleted without conducting a second round of factor analysis^[68], while another school of thought conducted the second round of factor analysis to check if all the variables are still grouped in the same component^[69]. In this study, a cross-check of the grouping of the variables in the same component was determined in the second round of the factor analysis. Since all the variables in the second-factor analysis are above the minimum threshold of 0.3, and all the variables are still grouped in their original components, a new table to report the results was not provided because of the word limit in scholarly articles. However, the 'lack of government/legislative support (BR20)' was not considered in the subsequent analyses to avoid negative impacts on the reliability and validity of the construct^[70].

Table 2. Factor analysis of Barriers to EMS Implementation.

Factors	Variables	Factorloading	Alpha value
KMO = 0.854			
KB1-Process-related barriers	BR14-Complex documentation process	0.790	0.824
	BR5-Multi-layered sub-contracting bottleneck	0.769	
	BR1-High costs of EMS implementation	0.757	
	BR19-Lack of environmentally friendly technologies and materials	0.402	

KB2-Knowledge-related barriers	BR6-Low awareness of EMS	0.854	0.884
	BR3-Difficulty in dealing with environmental issues	0.778	
	BR11-Lack of specialists in environmental issues	0.763	
	BR18-Lack of knowledge of certifiers systems	0.724	
	BR15-Lack of training and education about EMS	0.504	
	BR7-Unclear guidelines for EMS implementation	0.414	
KB3-Culture-related barriers	BR13-Limited pressure from stakeholders	0.672	0.822
	BR17-Negative attitudes of employees	0.588	
	BR4-Ambiguity in interpretations of EMS	0.568	
	BR9-High disintegration of construction process	0.504	
	BR10-Time consuming for improving environmental performance	0.456	
KB4-Stakeholders-related barriers	BR2-Organization resistance to change	0.667	0.799
	BR12-Lack of top management support	0.537	
	BR8-Lack of leading initiative among construction companies	0.509	
	BR16-Weak environmental culture	0.485	
	BR20-Lack of government /legislative support	0.276	

Italic variable: the barrier that was deleted in subsequent analyses because of low factor loading; KMO: Kaiser-Meyer-Olkin; BR: barriers; EMS: environment management system.

The internal consistency of the variables in each component was checked using Cronbach's alpha value and shown in Table 2. The alpha values generated were 0.824 for process-related barriers, 0.884 for knowledge-related barriers, 0.822 for culture-related barriers, and 0.799 for stakeholders-related barriers. The alpha values generated are above 0.6 and can be considered acceptable to measure the reliability of the variables grouped in each factor^[68].

The four factors generated are process-related, knowledge-related, industry culture-related, and stakeholders-related barriers. Since giving names to factors generated in factor analysis is more of an art, the authors used their judgment to label the factors. The name largely reflects the constituting variables in each component and can be considered acceptable for the study.

4.2 Prioritization of EMS barriers

Table 3 shows the mean score of the variables that constitute the barriers, the main factors generated, and associated weightings calculated using equations (1) and (2), respectively necessary for prioritizing the barriers. The mean values of all the barriers to EMS implementation range from 4.874 to 6.080. The mean value of the factor generated is the total sum of all the mean scores of the constituting elements. For example, the value of stakeholders-related barriers (KB4) is the addition of the mean scores 'organization resistance to change (BR2, M = 5.700)', 'lack of top management support (BR12, M = 5.874)', 'lack of leading initiative among construction companies (BR8, M = 5.550)', and 'weak environmental culture (BR16, M = 5.883)'.

Table 3. Mean score, weighting and membership function of the EMS barriers.

Barriers	Mean	Weighting	MFs (Level 2)								MFs (Level 1)							
KB1-Process-related barriers	22.355	0.208									0.012	0.018	0.040	0.102	0.242	0.330	0.261	
BR14-Complex documentation process	5.510	0.246	0.02	0.01	0.05	0.11	0.24	0.33	0.25									
BR5-Multi-layered sub-contracting bottleneck	5.514	0.247	0.01	0.01	0.05	0.13	0.26	0.34	0.20									
BR1-High costs of EMS implementation	5.581	0.250	0.02	0.02	0.03	0.08	0.26	0.34	0.26									
BR19-Lack of environmentally	5.750	0.257	0.00	0.03	0.03	0.09	0.21	0.31	0.33									

friendly technologies and materials																			
KB2-Knowledge-related barriers	35.070	0.326											0.007	0.017	0.028	0.088	0.195	0.366	0.311
BR6-Low awareness of EMS	6.080	0.173	0.00	0.01	0.03	0.07	0.13	0.36	0.41										
BR3-Difficulty in dealing with environmental issues	5.664	0.162	0.01	0.04	0.01	0.09	0.19	0.43	0.25										
BR11-Lack of specialists in environmental issues	5.870	0.167	0.01	0.01	0.03	0.06	0.22	0.39	0.29										
BR18-Lack of knowledge of certifiers systems	5.770	0.165	0.01	0.01	0.06	0.08	0.25	0.32	0.28										
BR15-Lack of training and education about EMS	5.942	0.169	0.01	0.02	0.01	0.09	0.19	0.32	0.37										
BR7-Unclear guidelines for EMS implementation	5.744	0.164	0.00	0.01	0.03	0.14	0.19	0.38	0.26										
KB3-Culture-related barriers	27.051	0.252											0.013	0.045	0.039	0.125	0.251	0.322	0.211
BR13-Limited pressure from stakeholders	5.590	0.207	0.00	0.05	0.02	0.09	0.29	0.32	0.23										
BR17-Negative attitudes of employees	5.352	0.198	0.03	0.05	0.01	0.17	0.24	0.27	0.24										
BR4-Ambiguity in interpretations of EMS	5.484	0.203	0.00	0.03	0.07	0.15	0.18	0.39	0.19										
BR9-High disintegration of construction process	5.751	0.213	0.00	0.03	0.01	0.08	0.29	0.36	0.23										
BR10-Time consuming for improving environmental performance	4.874	0.180	0.04	0.07	0.09	0.14	0.25	0.26	0.16										
KB4-Stakeholders-related barriers	23.007	0.214											0.002	0.007	0.032	0.109	0.245	0.350	0.258
BR2-Organization resistance to change	5.700	0.248	0.01	0.03	0.04	0.08	0.22	0.33	0.29										
BR12-Lack of top management support	5.874	0.255	0.00	0.00	0.02	0.08	0.24	0.43	0.25										
BR8-Lack of leading initiative among construction companies	5.550	0.241	0.00	0.00	0.03	0.19	0.23	0.38	0.18										
BR16-Weak environmental culture	5.883	0.256	0.00	0.00	0.04	0.09	0.29	0.26	0.31										

BR: barriers; EMS: environment management system.

$$\text{MeanScore}(\mu i)=\frac{\sum_{i=1}^N U_i Y_i}{N}$$

(1)

$$\text{Weighting}(W i)=\frac{\mu i}{\sum_{i=1}^5 \mu_i}, 0 \leq W i \leq 1, \sum(W i)=1$$

(2)

Table 3 also indicates the FSE of the variables of the barriers to EMS implementation and the associated principal components. For example, the percentage of the rating for the variable ‘lack of top management support (BR12)’ is 0.0%, 0.0%, 1.9%, 7.5%, 23.6%, 42.5%, and 24.5%, respectively. Thus, the MF using equation (3) are (0.00, 0.00, 0.02, 0.08, 0.24, 0.43, 0.25) in which MF_{mv} which stood for the MF of a variable mv; X_{bmv} (b = 1, 2, 3, 4, 5, 6, 7) represents the percentage of a score the respondents assigned to a variable mv; and X_{bmv}/V_b explains the relation between X_{bmv} and its associated grade alternative based on the rating scale.

$$MF_{mv} = \frac{X_{1mv}}{M_1} + \frac{X_{2mv}}{M_2} + \frac{X_{3mv}}{M_3} + \frac{X_{4mv}}{M_4} + \frac{X_{5mv}}{M_5} + \frac{X_{6mv}}{M_6} + \frac{X_{7mv}}{M_7} \quad (3)$$

The MF of a principal component (C_i) is calculated as a product of the fuzzy matrix of the MFs (R_i) of its associated variables and the weighting indices. D_i and R_i can be computed using equations (4) and (5), respectively. The MF of the four factors generated explaining the barriers to EMS implementation was also calculated using equations (4) and (5). Therefore, the MF of stakeholders-related barriers (KB4) is (0.002, 0.007, 0.032, 0.109, 0.245, 0.350, 0.258).

$$D_i = \begin{bmatrix} MF_{mi1} \\ MF_{mi2} \\ MF_{mi3} \\ \dots \\ MF_{min} \end{bmatrix} = \begin{bmatrix} X_{1mi1} & X_{2mi1} & X_{3mi1} & X_{4mi1} & X_{5mi1} \\ X_{1mi2} & X_{2mi2} & X_{3mi2} & X_{4mi2} & X_{5mi2} \\ X_{1mi3} & X_{2mi3} & X_{3mi3} & X_{4mi3} & X_{5mi3} \\ \dots & \dots & \dots & \dots & \dots \\ X_{1min} & X_{2min} & X_{3min} & X_{4min} & X_{5min} \end{bmatrix} \quad (4)$$

$$P_i = W_i \cdot D_i = (w_1, w_2, w_3, \dots, w_n) \cdot \begin{bmatrix} X_{1mi1} & X_{2mi1} & X_{3mi1} & X_{4mi1} & X_{5mi1} \\ X_{1mi2} & X_{2mi2} & X_{3mi2} & X_{4mi2} & X_{5mi2} \\ X_{1mi3} & X_{2mi3} & X_{3mi3} & X_{4mi3} & X_{5mi3} \\ \dots & \dots & \dots & \dots & \dots \\ X_{1min} & X_{2min} & X_{3min} & X_{4min} & X_{5min} \end{bmatrix} = (r_{i1}, r_{i2}, r_{i3}, \dots, r_n) \quad (5)$$

Finally, **Table 4** shows the computation of the significant index, and the ranks of the factors generated, illustrating the barriers to EMS implementation using equation (6). The significance index of the principal component is a multiplication of the fuzzy evaluation matrix (P_i) and the grade rating scale (M_i). Based on the computation, the knowledge-related barrier (KB2) is ranked highest with a significant index of 5.825, followed by stakeholders-related barriers (KB4), and process-related barriers (KB1), while the culture-related barriers (KB3) are the least with a significant index of 5.384.

Table 4. Significant index computation of principal components of EMS barriers.

Factors	Significant Index Calculation	S.I.	Rank
KB1	(0.012 × 1) + (0.018 × 2) + (0.040 × 3) + (0.102 × 4) + (0.242 × 5) + (0.330 × 6) + (0.261 × 7)	5.593	3
KB2	(0.007 × 1) + (0.017 × 2) + (0.088 × 3) + (0.195 × 4) + (0.366 × 5) + (0.366 × 6) + (0.311 × 7)	5.825	1
KB3	(0.013 × 1) + (0.045 × 2) + (0.039 × 3) + (0.125 × 4) + (0.251 × 5) + (0.322 × 6) + (0.211 × 7)	5.384	4
KB4	(0.002 × 1) + (0.007 × 2) + (0.032 × 3) + (0.109 × 4) + (0.245 × 5) + (0.350 × 6) + (0.258 × 7)	5.679	2

KB1: process-related barriers; KB2: knowledge-related barrier; KB3: culture-related barriers; KB4: stakeholders-related barriers; EMS: environment management system.

$$\text{Significant index} = \sum_{i=1}^n (P_i X M_i) \quad (6)$$

From the results of the significant index in **Table 4**, the prioritized order of EMS barriers includes knowledge-related barriers (KB2), stakeholders-related barriers (KB4), process-related barriers (KB1), and culture-related barriers (KB3), respectively. The conceptual pattern of the barriers to EMS implementation in the construction industry based on their significant index is also illustrated in **Figure 2**.

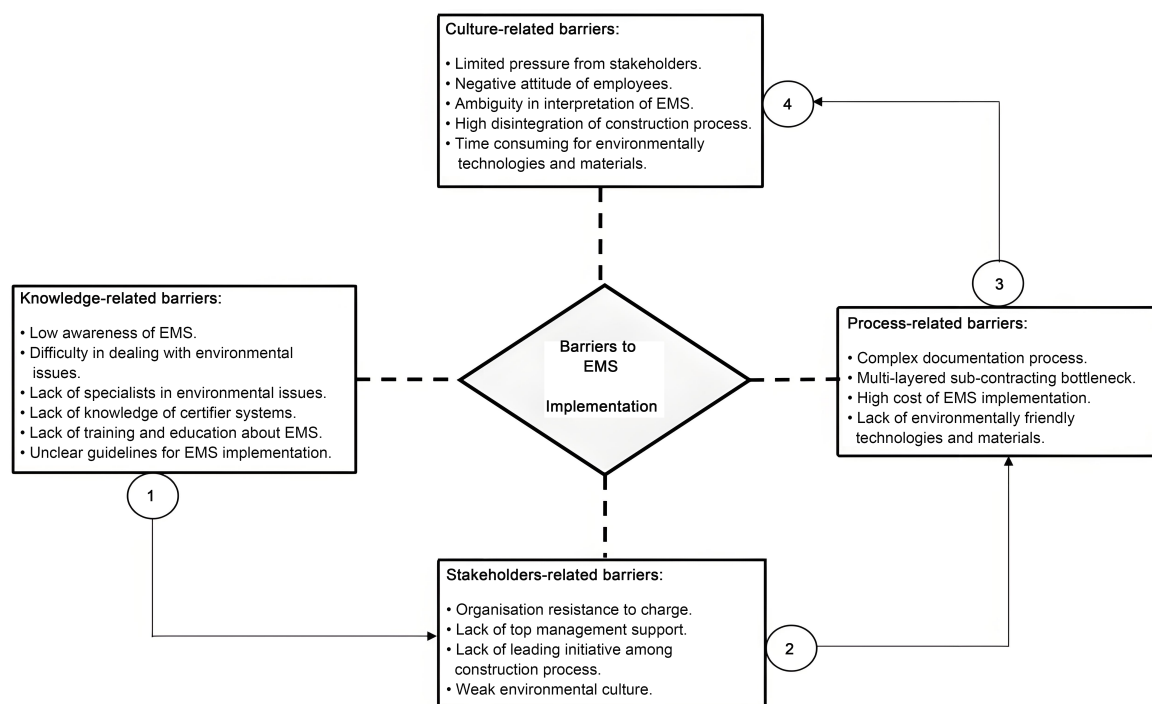


Figure 2. Prioritization of the barriers to EMS implementation in the construction industry. EMS: environment management system.

4.3 Relationships between the barriers to EMS implementation

To determine the relationships between the four components of barriers, ISM was adopted in this study. ISM combines words; digraphs; and discrete mathematics for structuring complex phenomena^[74]. The methodology entails five major steps, namely developing structural self-interaction matrix (SSIM), initial reachability matrix, final reachability matrix, partitioning of levels, and Matriced' Impacts Croise's Multiplication Appliquée a UN Classement (MICMAC) analysis^[72,73], which were followed to develop an ISM-based model for the barriers to EMS implementation in this study.

4.3.1 Structural self-interaction matrix

The use of four symbols/alphabets (V, A, X and O) was employed to develop SSIM to indicate the direction of the relationship between two barriers, 'i' and 'j'. Alphabet 'V' means that barrier 'i' will dominate in the direction of barrier 'j'; 'A' implies that barrier 'j' will dominate in the direction of barrier 'i'; 'X' implies that both barriers 'i' and 'j' will dominate in the direction of each other; and 'O' symbolizes that the barriers 'i' and 'j' are not related to each other. The development of SSIM for components of the barriers to EMS implementation is shown in Table 5. The explanation with the use of the above symbols is as follows: KB1 dominates to KB3 therefore, symbol 'V' was inserted in cell (KB1-KB3) of SSIM table; KB4 dominates to KB3, so symbol 'A' has been inserted in cell (KB3-KB4), and so on.

Table 5. Structural self-intersection matrix (SSIM) for the barriers to EMS implementation.

Group of barriers	KB4	KB3	KB2	KB1
KB1: Process-related barriers	X	V	A	X
KB2: Knowledge-related barriers	V	V	X	
KB3: Culture-related barriers	A	X		
KB4: Stakeholders-related barriers	X			

KB1: process-related barriers; KB2: knowledge-related barrier; KB3: culture-related barriers; KB4: stakeholders-related barriers; EMS: environment management system.

4.3.2 Initial reachability matrix

The SSIM obtained in Table 5 was converted into an initial reachability matrix by replacing the four symbols (V, A, X and O) with binary digits (0 and 1) using the following rules:

1. If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0.

2. If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.
3. If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 1.
4. If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 0.

Table 6 shows the initial reachability matrix of the barriers to EMS adoption.

Table 6. Initial reachability matrix of the barriers to EMS implementation.

Group of barriers	KB4	KB3	KB2	KB1
KB1: Process-related barriers	1	1	0	1
KB2: Knowledge-related barriers	1	1	1	1
KB3: Culture-related barriers	0	1	0	0
KB4: Stakeholders-related barriers	1	1	0	1

KB1: process-related barriers; KB2: knowledge-related barrier; KB3: culture-related barriers; KB4: stakeholders-related barriers; EMS: environment management system.

4.3.3 Final reachability matrix

The initial reachability matrix was checked for transitivity rule to form the final reachability matrix. The transitivity rule explains: if barrier 1 relates to barrier 3, and barrier 3 relates to barrier 4; then barrier 1 necessarily relates to barrier 4. This was checked in the initial reachability matrix (Table 6), to produce the final reachability matrix (Table 7). The driving power and dependence power were calculated by adding the number of 1s on the rows and columns respectively. The summation of the driving power and dependence power were finally computed for cross-checking.

Table 7. Final reachability matrix of the barriers to EMS implementation.

Group of barriers	KB1	KB2	KB3	KB4	Driving power
KB1: Process-related barriers	1	0	1	1	3
KB2: Knowledge-related barriers	1	1	1	1	4
KB3: Culture-related barriers	0	0	1	0	1
KB4: Stakeholders-related barriers	1	0	1	1	3
Dependence power	3	1	4	3	11/11

KB1: process-related barriers; KB2: knowledge-related barrier; KB3: culture-related barriers; KB4: stakeholders-related barriers; EMS: environment management system.

4.3.4 Partitioning of levels

The final reachability matrix was used for the partitioning of levels. This was necessary to identify the important levels of a group of barriers to EMS implementation. Table 8 shows the first iteration in the process of partitioning of levels. The reachability set consists of the barrier itself and other barriers it may impact, and the antecedent set consists of the barrier itself and other barriers that may impact it^[74]. The intersection set is the barriers that constitute the barriers that are reflected in both the reachability set and the antecedent set. The barriers with the same intersection and reachability sets were assigned level 1 in the ISM hierarchy and thus discarded in the subsequent iterations. Table 9 shows that “culture-based barriers (KB3)” had the same reachability and intersection set. Therefore, it was assigned the top level (level 1) of the ISM hierarchy. The iteration was repeated, and both process-related barriers (KB1) and stakeholders-related barriers (KB4) were assigned to the second level (Table 9) accordingly.

Table 8. First iteration for partitioning of levels of the barriers to EMS implementation.

Group of barriers	Reachability set	Antecedent set	Intersection set	Level
KB1: Process-related barriers	1,3,4	1,2,4	1,4	First level
KB2: Knowledge-related barriers	1,2,3,4	2	2	
KB3: Culture-related barriers	1	1,2,3,4	1	
KB4: Stakeholders-related barriers	1,3,4	1,2,4	1,4	

KB1: process-related barriers; KB2: knowledge-related barrier; KB3: culture-related barriers; KB4: stakeholders-related barriers; EMS: environment management system.

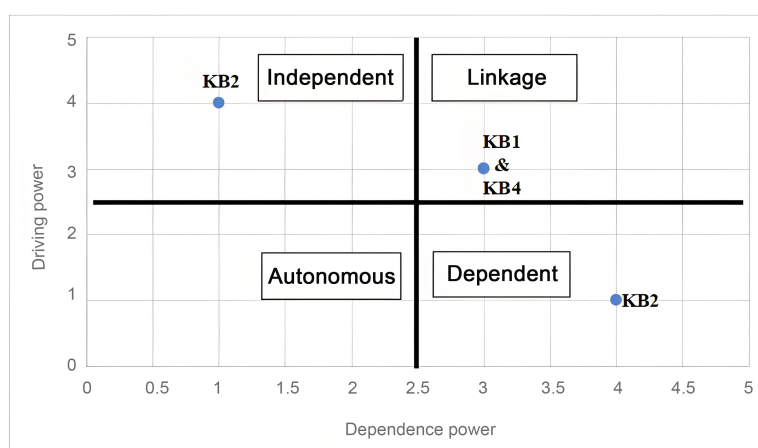
Table 9. Final iteration for partitioning of levels the barriers to EMS implementation.

Group of barriers	Reachability set	Antecedent set	Intersection set	Level
KB1: Process-related barriers	1,4	1,2,4	1,4	Second level
KB2: Knowledge-related barriers	1,2,4	2	2	Third level
KB4: Stakeholders-related barriers	1,4	1,2,4	1,4	Second level

KB1: process-related barriers; KB2: knowledge-related barrier; KB3: culture-related barriers; KB4: stakeholders-related barriers. EMS: environment management system.

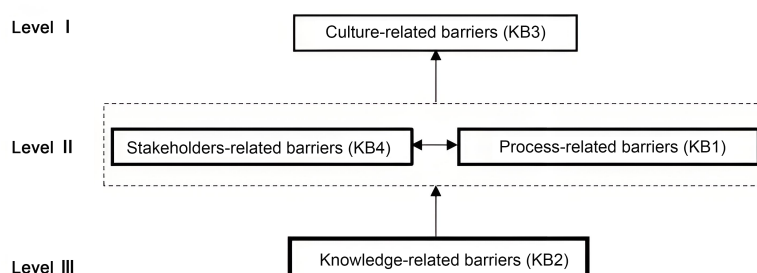
4.3.5 MICMAC analysis

The aim of conducting MICMAC analysis was to validate the developed ISM-based model. The analysis involved the classification of each barrier into four parts, namely autonomous, linkage, independent, and dependent based on the driving and dependence power. Autonomous barriers represent barriers with weak driving power and weak dependence power; linkage barriers imply barriers with strong driving power and strong dependence power; dependent barriers denote barriers with weak driving power and strong dependence power, while independent barriers represent barriers with strong driving power and weak dependence power^[75]. The classification of the barriers in the MICMAC analysis is shown in Figure 3. In this study, two groups of barriers (KB1 and KB4) reflected strong driving and dependence power and were thus classified under linkage factors. “Knowledge-related barriers (KB2) were classified under dependent factor, while “culture-related barriers (KB3)” were classified as independent barriers based on their driving and dependence power.

**Figure 3.** Digraph and MICMAC analysis of the groups of barriers. MICMAC: Matriced' Impacts Croise's Multiplication Appliquée a UN Classement.

4.3.6 ISM-based model formation of the barriers to EMS implementation

The different levels of each group of barriers to EMS implementation indicated in Table 8 and Table 9 were used to develop an ISM-based hierarchical model. As shown in Figure 4, “knowledge-related barriers (KB3)” are shown at the bottom of the ISM hierarchy (level 3), implying that it is the most critical of the group of barriers. Figure 4 also shows that both stakeholder-related barriers (KB4) and process-related barriers (KB1) are at level two, while culture-related barriers occupy the first level of the ISM hierarchy.

**Figure 4.** ISM-based model of the barriers to EMS implementation in the construction industry. ISM: interpretive structural modelling; EMS: environment management system.

5. Discussion

From the results of the FSE (Table 4) and the ISM-based model (Figure 4), the barriers to EMS implementation are discussed in the order of knowledge-related barriers (KB2), stakeholders-related barriers (KB4), process-related barriers (KB1), and culture-related barriers (KB4) respectively.

5.1 Knowledge-related barriers

The ‘knowledge-related barriers (KB2)’ comprised of low awareness of EMS (BR6), difficulty in dealing with environmental issues (BR3), lack of specialists in environmental issues (BR11), lack of knowledge of certifiers systems (BR18), lack of training and education about EMS (BR15), and unclear guidelines for EMS implementation (BR7). Interestingly, all the barriers in this group show a knowledge deficiency of EMS implementation strategies in the construction industry and are denoted as critical in both FSE and ISM analyses. The limited awareness of EMS and its indispensable advantages to society can be linked to the level of knowledge on environmental-related matters among construction professionals in developing and developed nations such as Egypt^[19] and Sweden^[6]. It can also be an indication of a knowledge gap, such as in access to environmental information on the detrimental impacts of construction processes between construction establishments in developed and developing nations. The deficient knowledge of the awareness of EMS can culminate in other factors identified in this group. It is logical for a lack of knowledge of EMS in developing nations or construction establishments to culminate in difficulty in dealing with environmental issues^[16]. Organizations with pro-environmental mindsets and concepts may find practical solutions for materials and construction processes that endanger the environment. However, the impetus to overcome environmental consequences in an organization can emanate from the awareness of EMS tools such as ISO 14,000 series and BS7750, amongst others^[13,29]. Therefore, the paucity of knowledge can be referred to as a key barrier to EMS implementation in construction organizations.

It is also interesting to note that the lack of specialists in environmental issues (BR11) dovetailed into knowledge-related barriers in this study. It is not uncommon for construction professionals to seek professional certification to become specialists in areas of innovation and safety concern^[76]. Although construction professionals are recently seeking green certification^[77,78], the awareness level and knowledge of EMS remain minimal. It is normal for the availability of specialists to inform the need for a unique certifier system and possibly the domestication of a certification system for the construction environment^[9,51]. This can also create a platform for the need for training and education about EMS to construction professionals interested in enhancing their pro-environmental knowledge and other construction stakeholders who lack knowledge of EMS. Although unclear guidelines for EMS implementation have the least factor loading in this study, they can also be a crucial barrier to EMS implementation in the construction industry. Guidelines are pathways to undertake activities and processes, especially for innovative methodologies or approaches^[51]. Therefore, the non-availability of the guideline may impede the implementation of EMS.

5.2 Stakeholders-related barriers

In this study, ‘stakeholders-related barriers (KB4)’ entail organization resistance to change (BR2), lack of top management support (BR12), lack of leading initiative among construction companies (BR8), and weak environmental culture (BR16). It is worth noting that all four barriers (BR2, BR12, BR8, and BR16) encompass environmental issues that hover around key stakeholders such as organizations, top management, and construction professionals. Construction stakeholders play indispensable roles in actualizing environmental sustainability^[11]. Resistance of both organizations and construction professionals to change from the traditional pattern and work process is constantly reported in the construction industry^[19,23,60]. The pro-environmental behavior of construction stakeholders to embrace the EMS initiative (stakeholders without resistance to change) may be hindered by a lack of top management support^[44]. Therefore, top management officers play a crucial role in EMS implementation. The lack of leading initiatives among construction companies has also been revealed as a key barrier to EMS implementation in the construction industry. Taking the lead in pro-environmental initiatives may be daunting in a region where the need to be environmentally conscious is not well regarded^[27]. Although large-sized construction companies may be capable of leading in environmental concerns^[19], most construction firms in developing nations are medium-, small- or micro-sized enterprises^[61]. Therefore, large-sized construction establishments may not be proactive, or the impact of their leading role may not be well embraced or well felt in the industry. On the other hand, the nonchalant environmental culture of the construction industry may also jeopardize the need for EMS implementation.

5.3 Process-related barriers

Based on the analyses, complex documentation process (BR14), multi-layered sub-contracting bottleneck (BR5), high costs of EMS implementation (BR1), and lack of environmentally friendly technologies and materials (BR19) point to ‘process-related barriers (KB1)’ in this study. As indicated in past studies, EMS implementation entails a complex documentation process because the right infrastructure is required for its effectiveness. The multi-layered sub-contracting bottleneck of EMS implementation has been regarded as a key barrier in previous investigations^[27]. Perhaps because of the limited electronic and internet connectivity in developing nations, the multi-layered bottlenecks may persist to hinder the process of EMS implementation in the construction industry. Interestingly, the high cost of EMS implementation is also grouped as a process-related barrier in this construct. EMS implementation requires significant financial expenses to procure pro-environmental materials, environmental certification, and

assessment costs, amongst others^[23]. Because most construction enterprises in developing nations are SMEs who may be more concerned with organizational growth and survival, their level of embracing EMS may be low. In other words, the high cost required for EMS implementation can contribute to financial stress on most construction organizations in developing countries^[43]. On the other hand, the fact that some environmentally friendly materials are often imported may also constitute barriers to EMS implementation. This does not imply that environmentally friendly materials cannot be locally sourced, but the lack of technologies to uplift the primitive façade of local materials to a close par with other imported materials may be a key hindrance.

5.4 Culture-related barriers

Five of the barriers, namely limited pressure from stakeholders (BR13), negative attitudes of employees (BR17), ambiguity in interpretations of EMS (BR4), high disintegration of the construction process (BR9), and time-consuming for improving environmental performance (BR10) are labelled 'culture-related barriers (KB3)'. Certain organizational or industry culture attributed to the construction industry contributes to the slow implementation of innovative methodologies or approaches. Construction clients can be reluctant to utilize pro-environmental construction materials and construction processes, possibly because of the high initial cost^[16,38]. On the other hand, the negative attitude of employees and the reluctance of construction professionals to embrace new initiatives has also been reported in past studies^[27,49]. Therefore, negative attitudes could be regarded as a common norm for professionals in the construction industry. The numerous construction parties and supply chains involved in the execution of typical construction projects, which describe the high disintegration of the construction process, may culminate as a barrier to EMS implementation. This can also explain the time required for improving or canvassing environmental performance among construction stakeholders^[16,60].

6. Recommendations and Theoretical Implications

6.1 Recommendations

Based on the findings of this study, the barriers to EMS implementation in the construction industry are knowledge-related barriers, stakeholder-related barriers, process-related barriers, and culture-related barriers, respectively. To address these four-pronged barriers to EMS implementation, practical recommendations are essential to construction professionals, stakeholders, construction establishments, and others.

First, knowledge-related barriers are revealed as foundational problems to EMS implementation in the construction industry. To minimize the deficient knowledge of EMS in the construction industry of developing nations, there is a need to provide training and adequate resources to construction professionals and organizations. To further ensure the deliverability and effectiveness of the EMS training to professionals and other stakeholders, trainers should use knowledge management tools. It is crucial to embrace and utilize the guidelines documented in the ISO 14001 standard or other standards in construction organizations to manage their environmental impact adequately. The results of this study also indicated that stakeholder-related barriers are significant barriers to EMS implementations. Therefore, it is suggested that all construction stakeholders involved in the supply chain of construction projects be adequately briefed on the importance of EMS to their business practices and society. The top management officials should also be educated on the benefits and opportunities of EMS in construction organizations through case studies, especially from developed nations. Through this, subordinates in construction organizations can easily embrace pro-environmental behaviors in the daily delivery of professional services.

The third group of barriers noted in this study is process-related barriers, comprising complications of EMS implementation. To address the process-related barriers, collaborations between construction organizations in developed and developing nations can be useful in learning the stepwise process of EMS implementation. Collaboration between construction establishments, professional bodies, and higher institutions is also important to minimize the barriers in this classification. It is also important to note that the high cost of EMS implementation, regarded as a process-related barrier, can be addressed through the assistance of government organizations to provide subsidies on environmentally friendly materials. The government should also encourage manufacturing organizations to refurbish local construction materials that are environmentally friendly for use in construction projects. The government could construct an experimental building with refurbished local materials and provide details of the advantages, production cost, and lifecycle costs in comparison to similar projects constructed with materials that are not environmentally friendly. The sensitization of the results of the experimental projects could encourage construction clients and construction organizations to embrace local environmentally friendly construction materials.

Lastly, culture-related barriers to EMS implementation identified in this study also require practical recommendations. The limited pressure from stakeholders may result from a lack of government policy on EMS implementation. Therefore, it is advised that the government formulate policy with enforcement strategies for EMS implementation in the construction industry. Education and pro-environmental training and practicum, seminars, and conferences can be useful to combat some of the culture-related barriers. It is also important to suggest that construction organizations encourage employees with reward systems to address the negative attitude of construction professionals towards environmental sustainability.

6.2 Theoretical implications

This study contributes theoretically to EMS literature by identifying the barriers to EMS implementation and utilizing them for comprehensive classification, prioritization, and interrelationships. The ISM-based model of barriers to EMS implementation could help to understand the significant challenges facing EMS implementation in the construction industry of developing nations. Drawing from the results of the soft computing analysis (FSE) adopted and ISM in this study, construction stakeholders can understand the importance of addressing the barriers of EMS in the construction industry. The practical recommendations proposed in the study can be useful in curbing the barriers confronting EMS implementation in developing nations and developing a curriculum to address the paucity of knowledge on EMS implementation in the construction industry.

7. Conclusions, Limitations and Future Studies

The adverse effects of various construction material pollutants on construction workers' health and the entire society have received laudable criticism and investigations. As a result of this, developed nations have been proactive in addressing anti-environmentally compliant construction processes. This has led to the proposition of various mitigative measures, such as the use of nanomaterials and the promulgation of EMS tools often embraced in the construction industries of developed countries. Meanwhile, the construction industry in developing nations appeared not to be environmentally concerned due to some militating barriers. Therefore, this study investigated the barriers to EMS implementation through a survey of construction professionals to propose practical steps to ameliorate the barriers. The results of the exploratory factor analysis revealed the barriers to EMS implementation can be grouped into four. In the same view, the results of the soft-computing analysis indicated the order of significance, namely knowledge-related barriers, stakeholders-related barriers, process-related barriers, and culture-related barriers. The ISM also indicated that knowledge-related barriers are the core impediments to EMS implementation. Based on the findings, practical recommendations such as comprehensive training and education, collaborations among all construction stakeholders to enhance communication of EMS and provision of reward systems for pro-environmental practices were posited.

Although this study achieved the intended objectives, some limitations that can inform future studies were identified. The inputs from the government and legislation are crucial in the construction industry and other sectors^[79], and a lack of support from the government and their agencies could impact EMS implementation. Meanwhile, lack of government/legislative support (BR20) is not considered in the second round of factor analysis and FSE in this study because of the low factor loading. Therefore, it may be important to further understand the perceptions of construction professionals on the government's stand for EMS implementation. Perhaps the construction professionals opined that stakeholders might need to take the front lead in embracing pro-environmental practices, making the government's involvement easier to support the initiative.

This study investigated the barriers to EMS implementation in developing countries using the opinions of construction professionals in the Nigerian construction industry. One of the limitations of the study concerns the non-generalization of the results obtained because of the geographical limitation. Although the Nigerian construction industry represents a commercial hub in Africa and among developing nations, the fundamental barriers to EMS implementation may vary in other developing countries. In other words, EMS may be region-specific and may not apply to other regions or contexts. Therefore, investigating the fundamental barriers in different developing countries and comparing them with the results of this study is essential.

Another limitation of this study relates to the sample size. Although the 106-sample size used is justifiable to achieve the objectives of the study and the data analysis methods adopted, namely factor analysis and FSE, a larger sample size may allow for the conducting of more sophisticated analyses, such as structural equation modelling (SEM). The use of SEM can confirm the variables that converged into various EMS factors and use them to determine relationships with outcomes such as operational, financial, environmental and organizational performance metrics.

The study employed a quantitative approach using a survey to obtain the opinions of respondents on the barriers to EMS implementation obtained from the extant literature. Although anonymity and confidentiality of data provided by the target respondents were ensured in the survey, there may be bias based on the self-reporting method of data collection. Therefore, future studies can explore the barriers to EMS implementation in construction organizations using other methods such as observation or third-party reports^[77].

Future studies can also investigate the impact of EMS implementation on the outcomes of construction projects using multiple regression analysis, or SEM, among others. Future research can also consider a comprehensive study on the pros and cons of EMS implementation in the construction industry to encourage wide applications of pro-environmental construction materials and practices using a scientometric, bibliometric or systematic review process. Qualitative studies via case studies, focus groups and interviews of relevant stakeholders, government, construction professionals, construction workers, professional bodies, academia, and environmental advocates, among others, may be essential to identify other barriers that may not be included in this study. Furthermore, the order of priority or importance of individual barriers may also be confirmed via interpretive structure modelling in future studies rather than the groups of EMS barriers indicated via factor analysis. This can provide more interesting findings that can unveil other research enquiries.

Declarations

Author Contribution

Ojo LD: Investigation, data curation, writing-original draft.

Oladinrin OT: Validation, writing-review&editing.

Chan APC, Owusu EK: Writing-review&editing.

Conflicts of interest

Albert P. C. Chan is an Editorial Board member of the *Journal of Building Design and Environment*. The other authors declare that there are no conflicts of interest.

Ethical approval

Ethical review and approval were waived for this study because the questionnaire does not contain any implicating items relative to the image of the institution where the research was conducted.

Consent to participate

Informed consent was obtained from all subjects involved in the study.

Consent for publication

Not applicable.

Availability of data and materials

The dataset used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funding information

Not applicable.

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References

1. Carnahan S, Agarwal R, Campbell B, Franco A. The effect of firm compensation structures on the mobility and entrepreneurship of extreme performers. *Business*. 2010;920:1-43. Available from: <https://www2.census.gov/ces/wp/2010/CES-WP-10-06.pdf>
2. Cormier D, Magnan M, Van Velthoven B. Environmental disclosure quality in large German companies: economic incentives, public pressures or institutional conditions?. *Eur Account Rev*. 2004;14(1):3-39. [DOI]
3. Ofori G. Challenges of construction industries in developing countries: Lessons from various countries. In: 2nd International Conference on Construction in Developing Countries. 2000 Nov 15-17; Gaborone, Botswana. 2001. p. 1-13. Available from: <https://www.irbnet.de/daten/iconda/CIB8937.pdf>
4. Opoku DGJ, Agyekum K, Ayarkwa J. Drivers of environmental sustainability of construction projects: a thematic analysis of verbatim comments from built environment consultants. *Int J Constr Manage*. 2022;22(6):1033-1041. [DOI]
5. Marica S, Cetean V, Lazaroiu G. Unitary management and environmental performance by monitoring and protection of mineral resources for construction materials from Romania. *Build Environ*. 2008;43(6):1082-1090. [DOI]
6. Varnäs A, Balfors B, Faith-Ell C. Environmental consideration in procurement of construction contracts: current practice, problems and opportunities in green procurement in the Swedish construction industry. *J Clean Prod*. 2009;17(13):1214-1222. [DOI]
7. Sev A. How can the construction industry contribute to sustainable development? A conceptual framework. *Sustainable Dev*. 2009;17(3):161-173. [DOI]
8. Li CZ, Zhao Y, Xu X. Investigation of dust exposure and control practices in the construction industry: Implications for cleaner production. *J Clean Prod*. 2019;227:810-824. [DOI]
9. Campos LMS, Trierweiller AC, de Carvalho DN, Šelih J. Environmental management systems in the construction industry: a review. *Environ Eng Manage J*. 2016;16(2):453-460. [DOI]
10. Isa RB, Jimoh RA, Achuen E. An overview of the contribution of construction sector to sustainable development in Nigeria. *Net J Bus Manage*. 2013;1(1):1-16. Available from: https://www.netjournals.org/z_NJBM_13_017.html
11. Oladinrin TO, Ogunsemi DR, Aje IO. Role of construction sector in economic growth: Empirical evidence from Nigeria. *FUTY J Environ*. 2012;7(1):50-60. [DOI]

12. Fitriani H, Ajayi S. Barriers to sustainable practices in the Indonesian construction industry. *J Environ Plann Manage*. 2023;66(10):2028-2050. [DOI]
13. Boiral O. Corporate greening through ISO 14001: a rational myth? *Organ Sci*. 2007;18(1):127-146. [DOI]
14. Cao X, Li X, Zhu Y, Zhang Z. A comparative study of environmental performance between prefabricated and traditional residential buildings in China. *J Clean Prod*. 2015;109:131-143. [DOI]
15. Mazzi A, Toniolo S, Mason M, Aguiari F, Scipioni A. What are the benefits and difficulties in adopting an environmental management system? The opinion of Italian organizations. *J Clean Prod*. 2016;139:873-885. [DOI]
16. Horry R, Booth CA, Mahamadu AM, Manu P, Georgakis P. Environmental management systems in the architectural, engineering and construction sectors: a roadmap to aid the delivery of the sustainable development goals. *Environ Dev Sustainability*. 2022;24:10585-10615. [DOI]
17. Qian W, Hörisch J, Schaltegger S. Environmental management accounting and its effects on carbon management and disclosure quality. *J Clean Prod*. 2018;174:1608-1619. [DOI]
18. Umar UA, Shafiq N, Malakahmad A, Nuruddin MF, Khamidi MF. A review on adoption of novel techniques in construction waste management and policy. *J Mater Cycle Waste Manage*. 2017;19:1361-1373. [DOI]
19. Sakr DA, Sherif A, El-Haggag SM. Environmental management systems' awareness: an investigation of top 50 contractors in Egypt. *J Clean Prod*. 2010;18(3):210-218. [DOI]
20. Chen G, Wiedmann T, Hadjikakou M, Rowley H. City carbon footprint networks. *Energies*. 2016;9(8):602. [DOI]
21. United Nations. World Urbanization Prospects 2018 Highlights [Internet]; 2018. Available from: <https://www.un.org/development/desa/pd/news/world-urbanization-prospects-2018>
22. Sikdar PK. Environmental Management: Issues and Concerns. In: Sikdar PK, editor. *Environmental Management: Issues and Concerns in Developing Countries*. Cham: Springer; 2021. p. 1-21. [DOI]
23. Kola-Lawal C, Wood M, Alo B, Clark A. Factors in organisational environmental management system implementation-Developed vs. Developing country contexts. *J Sustainable Dev Energy Water Environ Syst*. 2014;2(4):408-421. [DOI]
24. Oladinrin OT, Ojo LD. Characterisation of the drivers of environmental management system implementation. *Eng Constr Archit Manage*. 2022;29(10):3868-3892. [DOI]
25. Ziegler A, Rennings K. Determinants of environmental innovations in Germany: Do organizational measures matter? Leibniz Centre for European Economic Research. 2004. Available from: https://ftp.zew.de/pub/zew-docs/dp/dp0430.pdf?_gl=1*1aljof0*_ga*MjAyNzc3NjQyMS4xNzM1NjExNzA3*_ga_KFD4G5CY27*MTczNTYxMTcwNy4xLjAuMTczNTYxMTcwNy4wLjAuMA..
26. González P, Sarkis J, Adenso-Díaz B. Environmental management system certification and its influence on corporate practices: evidence from the automotive industry. *Int J Oper Prod Manage*. 2008;28(11):1021-1041. [DOI]
27. Owolana VO, Booth CA. Stakeholder perceptions of the benefits and barriers of implementing environmental management systems in the Nigerian construction industry. *J Environ Eng Landscape Manage*. 2016;24(2):79-89. [DOI]
28. Ojo LD, Oladinrin OT, Obi L. Critical barriers to environmental management system implementation in the Nigerian construction industry. *Environ Manage*. 2021;68(2):147-159. [DOI]
29. De Camargo Fiorini P, Chiappetta Jabbour CJ, Lopes de Sousa Jabbour AB, Oliveira Stefanelli N, Fernando Y. Interplay between information systems and environmental management in ISO 14001-certified companies: Implications for future research on big data. *Manage Decis*. 2019;57(8):1883-1901. [DOI]
30. Handl G. Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration), 1972 and the Rio Declaration on Environment and Development, 1992. United Nations. 2012. Available from: https://legal.un.org/avl/pdf/ha/dunche/dunche_e.pdf
31. Emas R. The concept of sustainable development: definition and defining principles. *Brief GSDR*. 2015;2015:10-13140. Available from: https://sdgs.un.org/sites/default/files/documents/5839GSDR%202015_SD_concept_definiton_rev.pdf
32. Wang H, Dong C, Liu Y. Beijing direct investment to its neighbors: a pollution haven or pollution halo effect. *J Clean Prod*. 2019;239:118062. [DOI]
33. Valdevino de Siqueira M, de Medeiros Melo Neto O, Martins de Azevedo A, Bezerra ALR, Mendes LPT, Rios Ribeiro MM. Socio-environmental management of reclaimed asphalt pavement (RAP) through a socio-ecological system approach: governance, adaptation, and long-term stability. *Aust J Civ Eng*. 2023;21:1-11. [DOI]
34. Erdas C, Fokaides PA, Charalambous C. Ecological footprint analysis based awareness creation for energy efficiency and climate change mitigation measures enhancing the environmental management system of Limassol port. *J Clean Prod*. 2015;108:716-724. [DOI]
35. Ikram M, Zhou P, Shah SAA, Liu GQ. Do environmental management systems help improve corporate sustainable development? Evidence from manufacturing companies in Pakistan. *J Clean Prod*. 2019;226:628-641. [DOI]
36. Baek J. A new look at the FDI-income-energy-environment nexus: dynamic panel data analysis of ASEAN. *Energy Policy*. 2016;91:22-27. [DOI]
37. Kolk A. The social responsibility of international business: From ethics and the environment to CSR and sustainable development. *J World Bus*. 2016;51(1). [DOI]
38. Zhang B, Bi J, Liu B. Drivers and barriers to engage enterprises in environmental management initiatives in Suzhou Industrial Park, China. *Front Environ Sci Eng China*. 2009;3(2):210-220. [DOI]

39. Lo-Iacono-Ferreira VG, Capuz-Rizo SF, Torregrosa-López JI. Key Performance Indicators to optimize the environmental performance of Higher Education Institutions with environmental management system-A case study of Universitat Politècnica de València. *J Clean Prod.* 2018;178:846-865. [DOI]
40. Pacana A, Ulewicz R. Research of determinants motivating to implement the environmental management system. *Pol J Manage Stud.* 2017;16(1):165-174. [DOI]
41. Mas-Machuca M, Marimon F. Still implementing ISO 14000 for the same reasons. *Int J Qual Res.* 2019;13(1):115-130. [DOI]
42. Pacana A, Lew G, Kulpa W. Rating the quality of implementation of environmental management systems. *J Bus Retail Manage Res.* 2017;11(2):165-169. Available from: https://www.researchgate.net/publication/316583365_Rating_the_quality_of_implementation_of_environmental_management_systems
43. Alsiary WA. A critical investigation into the barriers and opportunities for environmental management systems 'EMSs' implementation for the delivery of environmental benefits to the Industrial City in Jeddah, KSA [dissertation]. Norwich: University of East Anglia; 2015. Available from: https://ueaeprints.uea.ac.uk/id/eprint/56836/1/Waleed_Alsiary-The_Thesis.pdf
44. Iyalomhe FO, Cirella GT, Russo A, Jensen A, Idogho P. Environmental management system for Nigeria's Higher Education: Two-Year pilot analysis. *Consilience.* 2017;18:84-110. [DOI]
45. Tam VWY, Shen LY, Yau RMY, Tam CM. On using a communication-mapping model for environmental management (CMEM) to improve environmental performance in project development processes. *Build Environ.* 2007;42(8):3093-3107. [DOI]
46. Shen LY, Tam VWY. Implementation of environmental management in the Hong Kong construction industry. *Int J Proj Manage.* 2002;20(7):535-543. [DOI]
47. Wang SQ, Tiong RLK, Ting SK, Ashley D. Evaluation and management of political risks in China's BOT projects. *J Constr Eng Manage.* 2000;126(3):242. [DOI]
48. Stevens PA, Batty WJ, Longhurst PJ, Drew GH. A critical review of classification of organisations in relation to the voluntary implementation of environmental management systems. *J Environ Manage.* 2012;113:206-212. [DOI]
49. Zutshi A, Sohal A. Environmental management system adoption by Australasian organisations: part 1: reasons, benefits and impediments. *Technovation.* 2004;24(4):335-357. [DOI]
50. Johnstone L. A systematic analysis of environmental management systems in SMEs: Possible research directions from a management accounting and control stance. *J Clean Prod.* 2020;244:118802. [DOI]
51. Ojo LD, Ogunsemi DR, Ogunsina O. Conceptual framework of value management adoption in the Nigerian construction industry. *Constr Innovation.* 2022;22(4):939-961. [DOI]
52. Ofori G, Gang G, Briffett C. Implementing environmental management systems in construction: lessons from quality systems. *Build Environ.* 2002;37(12):1397-1407. [DOI]
53. Hillary R. Environmental management systems and the smaller enterprise. *J Clean Prod.* 2004;12(6):561-569. [DOI]
54. Zeng SX, Tam CM, Deng ZM, Tam VWY. ISO 14000 and the construction industry: survey in China. *J Manage Eng.* 2003;19(3):107. [DOI]
55. Šelih J. Environmental management systems and construction SMEs: a case study for Slovenia. *J Civ Eng Manage.* 2007;13(3):217-226. [DOI]
56. Lam PTI, Chan EHW, Chau CK, Poon CS, Chun KP. Environmental management system vs green specifications: How do they complement each other in the construction industry? *J Environ Manage.* 2011;92(3):788-795. [DOI]
57. Raymond CM, Fazey I, Reed MS, Stringer LC, Robinson GM, Evely AC. Integrating local and scientific knowledge for environmental management. *J Environ Manage.* 2010;91(8):1766-1777. [DOI]
58. Gluch P, Räisänen C. What tensions obstruct an alignment between project and environmental management practices?. *Eng Constr Archit Manage.* 2012;19(2):127-140. [DOI]
59. Bravi L, Santos G, Pagano A, Murmura F. Environmental management system according to ISO 14001: 2015 as a driver to sustainable development. *Corp Soc Responsib Environ Manage.* 2020;27(6):2599-2614. [DOI]
60. Kehbila AG, Ertel J, Brent AC. Strategic corporate environmental management within the South African automotive industry: motivations, benefits, hurdles. *Corp Soc Responsib Environ Manage.* 2009;16(6):310-323. [DOI]
61. Saka AB, Chan DWM. Profound barriers to building information modelling (BIM) adoption in construction small and medium-sized enterprises (SMEs) An interpretive structural modelling approach. *Constr Innovation.* 2020;20(2):261-284. [DOI]
62. Moyanga D, Ojo LD, Awodele OA, Ogunsemi DR. Prioritizing the survival determinants of quantity surveying firms in economic contraction. *Eng Constr Archit Manage.* 2023;32(12):673-704. [DOI]
63. Flynn B, Pagell M, Fugate B. Survey research design in supply chain management: the need for evolution in our expectations. *J Supply Chain Manage.* 2018;54(1):1-15. [DOI]
64. Shan M, Liu WQ, Hwang G, Lye JM. Critical success factors for small contractors to conduct green building construction projects in Singapore: identification and comparison with large contractors. *Enviro Sci Pollut Res.* 2020;27:8310-8322. [DOI]
65. Arowoija VA, Oke AE, Ojo LD, Adelusi AO. Driving factors for the adoption of digital twin technology implementation for construction project performance in Nigeria. *J Constr Eng Manage.* 2024;150(1):05023014. [DOI]
66. Vagias WA. Likert-type scale response anchors. Clemson University. 2006. Available from: <https://cse.iitkgp.ac.in/~mainack/courses/2020-autumn/usesec/slides/Likert-Scale-Examples.pdf>
67. Finstad K. Response interpolation and scale sensitivity: Evidence against 5-point scales. *J Usability Stud.* 2010;5(3):104-110. Available from: <https://uxpajournal.org/response-interpolation-and-scale-sensitivity-evidence-against-5-point-scales/>

68. Leung M, Chan YS, Chong AML. Chinese Values and Stressors of Construction Professionals in Hong Kong. *J Constr Eng Manag.* 2010;136(12):1289-1298. [DOI]
69. Okoro CS, Musonda I, Agumba JN. Exploring the underlying structures of sustainability performance measures: a study of transportation projects in South Africa. *Int J Constr Manage.* 2022;22(8):1550-1558. [DOI]
70. Shrestha N. Factor analysis as a tool for survey analysis. *Am J Appl Math Stat.* 2021;9(1):4-11. [DOI]
71. Ansari MF, Kharb RK, Luthra S, Shimmi SL, Chatterji S. Analysis of barriers to implement solar power installations in India using interpretive structural modeling technique. *Renew Sustain Energy Rev.* 2013;27:163-174. [DOI]
72. Abuzeinab A, Arif M, Qadri MA. Barriers to MNEs green business models in the UK construction sector: An ISM analysis. *J Clean Prod.* 2017;160:27-37. [DOI]
73. Gan X, Chang R, Zuo J, Wen T, Zillante G. Barriers to the transition towards off-site construction in China: An Interpretive structural modeling approach. *J Clean Prod.* 2018;197:8-18. [DOI]
74. Attri R, Dev N, Sharma V. Interpretive structural modelling (ISM) approach: an overview. *Res J Manage Sci.* 2013; 2 (2): 1171. Available from: <https://www.isca.in/IJMS/Archive/v2/i2/2.ISCA-RJMS-2012-054.php>
75. Luthra S, Kumar S, Kharb R, Ansari MF, Shimmi SL. Adoption of smart grid technologies: An analysis of interactions among barriers. *Renew Sustain Energy Rev.* 2014;33:554-564. [DOI]
76. Karakhan AA, Gambatese JA. Identification, quantification, and classification of potential safety risk for sustainable construction in the United States. *J Constr Eng Manage.* 2017;143(7):04017018. [DOI]
77. Tucker JR, Pearce AR, Bruce RD, McCoy AP, Mills TH. The perceived value of green professional credentials to credential holders in the US building design and construction community. *Constr Manage Econ.* 2012;30(11):963-979. [DOI]
78. Darko A, Chan APC, Gyamfi S, Olanipekun AO, He BJ, Yu Y. Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. *Build Environ.* 2017;125:206-215. [DOI]
79. Fox P, Skitmore M. Factors facilitating construction industry development. *Build Res Inf.* 2007;35(2):178-188. [DOI]

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