Journal of Sustainable Construction Materials and Technologies

Volume 10 | Issue 2 Article 4

2025

Identification of Barriers and Drivers in the Adoption of Sustainable Construction Practices in the Turkish Construction Industry: Exploratory Factor Analysis

Tülay Çivici
Balikesir University, Faculty of Architecture, Çağış Campus, Balikesir, Türkiye, tulay@balikesir.edu.tr

Mustafa Serhan Ünlütürk
Balikesir University, Ayvalık Vocational School, Department of Architecture and City Planning, Ayvalık, Balikesir, Türkiye, serhanunltrk@gmail.com

Recommended Citation

Çivici, Tülay and Ünlütürk, Mustafa Serhan (2025) "Identification of Barriers and Drivers in the Adoption of Sustainable Construction Practices in the Turkish Construction Industry: Exploratory Factor Analysis," *Journal of Sustainable Construction Materials and Technologies*: Vol. 10: Iss. 2, Article 4.
https://doi.org/10.29187/2458-973X.1182
Available at: https://commons.yildiz.edu.tr/jscmt/vol10/iss2/4

JOURNAL OF SUSTAINABLE CONSTRUCTION MATERIALS AND TECHNOLOGIES 2025;10:188–202

RESEARCH ARTICLE

Identification of Barriers and Drivers in the Adoption of Sustainable Construction Practices in the Turkish Construction Industry: Exploratory Factor Analysis

Tülay Çivici [a,*], **Mustafa Serhan Ünlütürk** [b]

[a] Balikesir University, Faculty of Architecture, Çağış Campus, Balikesir, Türkiye
[b] Balikesir University, Ayvalık Vocational School, Department of Architecture and City Planning, Ayvalık, Balikesir, Türkiye

ABSTRACT

Although the importance of sustainability in the construction industry has been emphasised by many researchers and endorsed by many authorities, it is clear that the practices in the industry still need to be improved. The primary issue for adopting sustainable practices in the construction industry is identifying the barriers and drivers. For this reason, the study analysed the literature to identify the critical barriers and incentives for adopting sustainable practices in the construction industry. In light of the information from the literature, the necessary barriers and motivators in adopting sustainable practices in the construction industry were determined, and a questionnaire form was prepared. The questionnaire was applied to architectural offices, engineering offices, and contractor firms in the Turkish Construction Industry. The data obtained from the survey were analysed using SPSS statistical software. Research findings indicate that sustainable construction increases user comfort in the interior space and increases competition. In addition, although the initial construction cost of sustainable construction is high, its long-term profitability is undeniable. Sustainable buildings are energy efficient and environmentally friendly since they require less energy than traditional buildings while providing indoor comfort conditions. On the other hand, it is concluded that training people working in the construction industry on sustainable construction is insufficient, and training and certification systems should be developed in this regard.

Keywords: Sustainable construction practices, Critical barriers, Critical drivers

1. Introduction

Due to the increase in urban population density and the acceleration of industrial developments, wastes are left to nature, and natural resources are consumed unconsciously, resulting in irreversible destruction of the ecosystem [1, 2]. The construction industry must assume essential responsibilities in minimising these damages. The main reason is that the construction interacts directly and indirectly with the natural environment. "Sustainable construction (SC)" is shown as a response to the search for solutions on a global scale for a transformative change in the interaction of the construction with the natural environment due to the inadequacy of the measures to be taken on an individual or national scale and the limitation of the impact area [3, 4].

Sustainability first gained importance with the report "Our Common Future" by the Brundtland Commission of the United Nations World Commission on Environment and Development [5]. In the report, sustainable development is seen as a formula for

Received 29 December 2024; revised 3 May 2025; accepted 12 May 2025.
Available online 30 June 2025

* Corresponding author.
E-mail addresses: tulay@balikesir.edu.tr (T. Çivici), serhanunltrk@gmail.com (M. S. Ünlütürk).

https://doi.org/10.29187/2458-973X.1182

long-term prosperity [6], developing in a way that can serve the needs of both today and the future [7] and meeting the needs of today without compromising the ability of future generations to meet their own needs [8]. Sustainable development is linked to establishing a relationship between the natural environment and economic development [8, 9].

Sustainability has been defined by many researchers in the discipline. According to Ruckelshaus [10], it is "the doctrine that economic growth and development within the broadest boundaries of ecology will be achieved and maintained over time through mutual interaction". According to Robert C. Gilman, any system can continue functioning indefinitely without depleting the primary resources [Cited in 11]. Sustainability refers to the ability of a society, ecosystem, or any such ongoing system to continue to function into the indefinite future without being forced to decline through depletion or overloading of the essential resources on which that system depends [12]. Pierce [13] argues that sustainability "involves obtaining interchangeable resources, since non-renewable resources are physically scarce and ensuring that the environmental impacts and wastes arising from the use of resources do not exceed the Earth's capacity to sustain them [13, 14]. According to Miranda and Marulanda [15], sustainability must be understood from an integrated and holistic perspective. In this direction, it is the ability to spread to all areas of production, which remains topical today with increasing interest.

The construction industry is of central importance in determining the pace of progress towards sustainable development [15–20]. While some researchers [2, 21–23] consider SC (sustainable construction) as a subset of sustainable development, another study [24] characterizes SC as a strategy to achieve sustainable development. Sustainable construction (SC) should not be considered separately from sustainable urbanisation and development [15].

Studies [16, 21, 25–28] prove that the construction industry is the primary consumer of the natural environment. Previous studies show that the industry's sustainability in developing countries is dismal [29, 30]. According to Toriola-Coker et al. [7], every construction involves burning fossil fuels, carbon dioxide emissions, methane gas, and other waste products that pollute the environment, including air, water, and noise pollution, and the destruction of natural habitats. The construction industry, which is recognised as a major contributor to environmental degradation and pollution, is responsible for 45-65% of waste generation [4, 31, 32]. In developed countries, 40% of natural resources extracted in the construction industry are used, 70% of electrical energy, and 12-16% of all available water are consumed [33–37]. Darko et al. [38] emphasise that the construction industry consumes approximately 32% of global energy. The United Nations Environment Programme (UNEP) report states that 30–40% of the world's energy is used in buildings. In OECD countries, buildings account for 25–40% of total energy use, while in Europe, these criteria are up to 40-45%. A striking example is the emission of greenhouse gases (GHG) during the production and consumption of building materials, which cause global warming due to the use of natural resources in the construction industry, which produces about one-third of carbon emissions [26, 35–40]. Furthermore, the detrimental environmental impacts are noteworthy, in addition to the extensive ramifications exerted by the construction industry [41]. Energy and natural resources are consumed at varying levels and scales throughout the life cycle of a construction project, encompassing the phases of planning, construction, and demolition. [2, 15, 20, 21, 28, 33].

Davies and Davies [42] state gaps regarding SC practices in all construction practice areas. Karisma et al. [43] investigated the recycling and use of plastic waste in the construction industry in their study on reducing pollution and developing alternative building materials. The study results showed that using recycled plastics in the construction industry can significantly contribute to waste management and green building solutions [43]. Manoj [44] examines how IoT-enabled hot water curing applications can be integrated into the concrete curing process and the implications for SC. The study is a valuable reference for future research in SC and innovative building technologies [44]. In the construction industry of Kazakhstan, Tokbolat et al. [45] found that SC contributes to energy and material efficiency, thus reducing the life cycle costs of buildings. Çivici and Özlük [46] aimed to identify potential barriers to SC in the Turkish construction industry and recognized the lack of knowledge barrier, the lack of education barrier, the high investment cost barrier, the awareness barrier, the academic insufficiency barrier, the inadequate legal framework barrier, and the inadequate incentives barrier as potential barriers to SC practice. The results show that respondents perceive education and awareness barriers to sustainability at a higher level than investment costs, compared to other factors. According to Cobbinah et al. [47], while developed countries prioritise efficient resource use and reduce environmental impacts, developing countries face more significant challenges that hinder the adoption of sustainability.

Research [7, 20, 23, 45, 46, 48–52], especially from developing countries, reported that the cost of SC, lack of knowledge and awareness, lack of education barrier, inadequate perception and understanding, lack of regulatory policy and government support for SC practices are the significant barriers. Similarly, Andelin et al. [51] argue that since investors are not interested in sustainability and developers do not want sustainable buildings, builders are unwilling to build them. This, therefore, results in a reluctance to adopt the SC practice [50]. The construction industry has an essential share in development policies in developing countries such as Turkey. From this point of view, it is necessary to identify the barriers to the implementation of SC and the drivers to determine the strategies and policies that will be developed for successful implementation and widespread adoption. Therefore, it is essential to identify the barriers and drivers for development now and in the future. Therefore, the way forward for SC and monitoring progress is to determine the current situation [23, 46, 53–55]. However, there are discrepancies in the presentation of country-specific variations. The present study aims to contribute to the identification of these gaps using an analysis of the barriers and drivers of SC practices in the Turkish construction sector. The paucity of research focusing on developing countries such as Turkey is evident. This study will contribute to filling this gap. Furthermore, a holistic and comprehensive approach has been proposed, and the driving forces in SC applications are being addressed. The present study provides a thorough analysis of the barriers and driving forces. In this respect, the study makes a unique contribution to the field. Moreover, the studies conducted using the systematic literature review method to determine the barriers and drivers in SC applications were analysed, and a questionnaire was designed based on the systematic literature review results. In this respect, the study's methodology is a significant strength.

This study aims to identify the critical barriers and drivers for adopting SC practices in the construction industry. For this purpose, a systematic review of the literature has been carried out. The literature review identified and listed barriers and drivers from leading countries in SC practice. Although the studies focus on similar factors, the level of implementation of sustainable construction differs according to the countries' economic, political, and social structures [23, 46, 52, 55]. A questionnaire was designed based on the results of the systematic literature review. The data obtained from the questionnaire were analysed using statistical analysis methods. The study's results were not limited to identifying the factors that could be barriers to SC practices but also aimed to identify the drivers. For this reason, it differs from previous studies [e.g., 23, 46].

2. Materials and methods

The study used a mixed method consisting of a systematic literature review (SLR), a qualitative method, and a quantitative method, in which statistical analyses are performed. Firstly, the studies obtained using the SLR method were analyzed in depth. Then, the survey method was applied to investigate and explore the phenomenon of interest in the study population.

2.1. Systematic literature review (SLR)

It is observed that the boundaries of research on identifying barriers and drivers for adopting sustainable construction practices in the building industry are wide-ranging. For this reason, SLR (Systematic literature review) provides an opportunity to identify and select literature to enable an in-depth examination of the research topic [56].

In this study, the SCOPUS database was utilised as a comprehensive research environment for researchers. The search in the SCOPUS database was limited to titles, abstracts, and keywords containing the words "sustainable construction", "barrier", and 'driver', as well as synonyms (environment-friendly construction, green construction, obstacle, challenge, etc.). As a result of the search, 146 articles were obtained. In the search results, two articles were deleted because they were duplicates. Some of the records obtained were deleted because they contained studies from different disciplines. The remaining results were carefully refined by manually scanning keywords, titles, and abstracts according to the publication type. In this context, all documents obtained were analysed in full text, and 49 articles suitable for the scope of the research were examined in depth to create the item pool [57]. As a result, the relationship between barriers and drivers in adopting sustainable construction practices in the building industry was established, as listed in Table 1.

2.2. Questionnaire survey

The questionnaire study, including the item pool obtained from the SLR, constitutes the second research stage. The first part of the form prepared for the questionnaire study contains questions about demographic information such as the participants' experience, occupation, and company size. The second section includes the items obtained from the SLR result to be evaluated with a 5-point Likert scale. This section is grouped into 43 items related to the barriers in adopting construction practices and 39 items about the drivers. The level of agreement with each item in the questionnaire form was prepared to

Table 1. Barriers and Drivers in the construction industry.

Barriers and drivers in the construction industry		Reference
Barriers		
E1	Insufficient awareness of the differences between SC and traditional processes	[21, 26, 38, 27, 58, 48, 55, 59, 50]
E2	Resistance to change and insistence on traditional building production methods.	[25, 26, 34, 35, 37, 38]
E3	The perception that sustainable construction is complex.	[38, 58, 48, 59, 60, 61, 62]
E4	Lack of knowledge about SC among project participants (architects/engineers).	[8, 25, 36, 37]
E5	Lack of collaboration among stakeholders (architects, engineers, contractors, clients, etc.) SC practices.	[48, 55, 59]
E6	Lack of examples and experience in SC.	[2, 8, 27]
E7	Lack of awareness of SC benefits.	[27, 36, 60, 85]
E8	Lack of knowledge of SC standards.	[27, 36, 60, 63, 85]
E9	Lack of SC specialists, such as architects, engineers, and project managers.	[38, 59, 64]
E10	Lack of clarity in the implementation procedures of SC projects.	[59]
E11	Lack of clarity in the implementation procedures of SC projects, leading to conflicts/conflicts.	[59]
E12	Lack of clarity in SC project procedures, causing inadequate contracts	[58]
E13	Lack of clarity in SC project procedures causes inadequate contracts.	[36, 48, 55, 60, 85]
E14	Inability to implement SC due to variability in client demands/requests.	[2, 48, 58]
E15	International standards are unsuitable for the Turkish construction industry	[23, 65]
E16	The lack of conformity of international standards to the Turkish construction industry industry	[23, 65]
E17	Lack of incentives to encourage investment in SC, such as low-interest loans.	[2, 48]
E18	Insufficient legal sanctions for SC practices	[2, 27, 36, 48, 85]
E19	Lack of specific legislation (laws, regulations) for SC	[2, 8, 59, 68]
E20	The belief that SC projects will cause delays in delivery	[23, 65]
E21	Difficulties in scheduling SC projects and inability to set realistic project durations	[64, 65, 23, 48]
E22	The perception that there is no economic return on the investment made	[2, 48, 55]
E23	The belief that SC practice will not recover investment costs	[2, 48, 50, 64]
E24	High initial investment costs for SC	[2, 48, 55]
E25	Lack of knowledge and data on the costs of SC	[2, 26, 55]
E26	Lack of knowledge about green materials and technologies	[27, 36, 58, 60]
E27	Lack of clarity about the objectives of the use of green products	[2, 27]
E28	The limited availability of materials and equipment for SC	[2, 65]
E29	Uncertainty about the durability of green materials for SC	[2, 64, 65, 69]
E30	Difficulties in the supply of green materials for SC	[2, 64, 65, 69]
E31	The impact of green materials on the cost of SC	[2, 64]
E32	Limited local production of green materials for SC	[2, 65]
E33	Storage problems with green materials for SC	[2, 64, 65, 69]
E34	The limited number of green material suppliers for SC	[2, 64, 65, 69]
E35	Long supply periods for green materials in SC	[2, 64, 65, 69]
E36	Economic and political changes impacting material prices	[64]
E37	Lack of coordination between the academy and the industry	[71]
E38	Lack of SC courses in academic curricula	[71]
E39	Lack of or limited number of faculty members specialized in SC	[71]
E40	Lack of resource allocation for social responsibility projects in construction	[2, 71, 26, 38]
E41	The construction industry is characterised by high levels of risk and uncertainty	[58, 85]
E42	Small-scale projects, such as housing, are being implemented widely	[58, 85]
E43	Insufficient organizational culture for the integration of SC	[2]
Drivers		
G1	Increasing awareness of the benefits of SC.	[58, 48, 69]
G2	Increasing environmental awareness	[48]
G3	Improved environmental quality/reduced waste and CO2 emissions/improved water quality	[2, 48]
G4	Improved indoor environmental quality/increased user health and well-being	[2, 48]
G5	Increased awareness of the need to conserve natural resources and minimise losses	[26, 38, 59, 72]
G6	Social responsibility and an environmentally conscious approach to duties	[48]
G7	Increase user comfort/quality of life	[2, 50]
G8	Reducing energy costs	[2, 50]
]G9	Conservation of natural resources	[26, 38]
G10	Benefit to organisational image/improve organisational image	[2, 69]
G11	The necessity for efficient energy use/high energy efficiency	[2, 55]
G12	Establishing standards for future designs	[2]
G13	Educational attainment and experience	[2, 58, 55]
G14	Customer interest in environmentally friendly products/materials	[2, 48]

(Continued)

Table 1. Continued.

Barriers and drivers in the construction industry		Reference
Drivers		
G15	Organisational culture evolving	[2, 26, 38]
G16	Establishing an asset for the future	[2]
G17	Use of ecological materials	[73]
G18	Use of recyclable construction materials	[73]
G19	Pressure from customers	[48]
G20	Pressure from participants	[48]
G21	Customer satisfaction	[48]
G22	Regulatory conformity	[48]
G23	Government policies and regulations	[2, 58, 48, 55, 60]
G24	Certificate system in contract clauses	[48]
G25	Pressure in the international market/competition	[70, 74]
G26	Technological progress/innovation	[75, 76]
G27	Increased effective use of technologies	[76]
G28	The certification system ensures that quality parameters such as indoor comfort	[77, 78]
G29	Determination of performance measurement criteria through certification	[67]
G30	Quality guarantee certification	[67]
G31	Reduction in operating costs/, saving potential/reduction in building life cycle costs	[79, 80]
G32	Ease of marketing/advantage/increased product and competitive strength	[79, 80]
G33	High return on investment/reduced investment risk	[79, 80]
G34	Increasing the marketability of buildings	[79, 80]
G35	Increasing the monetary value of the building	[79, 80]
G36	High asset value	[79, 80]
G37	Maximise savings and profits	[79, 80]
G38	Increased access to green production/materials	[79, 80]
G39	Enhancing the designer's competence	[79, 80]

be evaluated with (1) Strongly Disagree, (2) Disagree, (3) Undecided, (4) Agree, and (5) Strongly Agree. In the questionnaire method used to investigate the phenomenon of interest in the survey study population, a pilot study was conducted to identify confusing or not fully understood statements to ensure that the statements were clear. In addition, the response time of the questionnaire was also determined. A total of 15 participants with more than five years of experience in the field participated in the pilot study. The final questionnaire was prepared, considering the comments and suggestions from the pilot study.

In construction research, the random sampling technique is widely used, where each member of the population is randomly selected from the population and has an equal chance of being selected as a sample [81]. This approach accurately represents the entire population [81, 82]. Therefore, the random sampling technique was used to select the participants for this study. The method used to calculate the sample size of the population is given below [81–83]. This approach accurately represents the entire population [81–84]. Therefore, the random sampling technique was used to select the participants for this study.

$$SS = \frac{1.96^2 \times 0.5\,(1-0.5)}{0.09^2} = 118.57 \approx 119 \;\; (\textit{as the minimum sample size})$$

The maximum margin of error for a 95 per cent confidence level $\approx$ *is* $\frac{1.96}{\sqrt{SS}} = \frac{1.96}{\sqrt{119}} = 0.18 > 0.09$ [60]

(SS = Sample Size; Z = Z value (1.96 for 95 percent confidence level); P = percentage picking a choice, expressed as a decimal (0.5 used for sample size needed); C = margin of error (9 percent)).

The research population comprises professionals in the Turkish construction industry, including architects, civil engineers, and contractors. The questionnaire was sent to 500 professionals selected by a simple random sampling method on 5 June 2023 via social media, e-mail, messaging, and call applications. The responses were accepted until 13 January 2024, and data were obtained from 129 architects, civil engineers, and contractors, including architecture, engineering, and contractor company employees. Akintoye [84] asserts that a response rate within the range of % 20% to 30% is acceptable for construction survey research. The margin is sufficient, and the minimum size is 119; therefore, 129 data points are also deemed acceptable.

The relative importance index (IRI) was determined by considering the respondents' responses according to their perception levels of drivers and barriers to SC practices in the Turkish construction industry. The IRI was determined for each reason, considering each specific perception level of the respondents

Table 2. Demographic characteristics of respondents.

Parameters	Respondents Number	Percent (%)
Experience (years)		
10–over	32	25
10–5	44	34
1–5	42	33
Professional		
Architect	60	47
Civil Engineer	32	25
Contractor	42	33
Company Type		
Architecture / Engineering Office	38	29
Contractor Company	39	30

using Eq. (1) [85].

$$IRI_k\,(\%) = \frac{5\,(n_5) + 5\,(n_4) + 5\,(n_3) + 2\,(n_2) + n_1}{5\,(n_5 + n_4 + n_3 + n_2 + n_1)} \times 100 \quad (1)$$

The overall IRI for each item for all participants was calculated as a weighted average of the IRI_k obtained from Eq. (1) [86], with all effect levels taken into account as follows:

$$Overall\ IRI\ (\%) = \frac{\sum_{k=1}^{k=5} (k \times IRI_k)}{\sum_{k=1}^{k=5} k} \times 100 \quad (2)$$

According to the data in Table 2, from the survey data received from 38 architectural offices, 22 engineering offices, and 17 contractor firms, the sample group consists of 60 architects, 32 civil engineers, and 42 contractors.

2.2.1. Analysing the survey data

2.2.1.1. Reliability analysis. Reliability analysis was performed to evaluate the internal consistency of the data obtained from the questionnaire study [87]. The Cronbach's alpha (α) coefficient value range is 0-1. As a generally accepted rule, Cronbach's alpha between 0.6 and 0.7 indicates an acceptable level of reliability. The reliability of the scales used in the study was analysed by determining Cronbach's Alpha (α) coefficients. The Cronbach Alpha (α) values obtained for the study scale are presented in Table 3. When interpreting the Cronbach Alpha (α) values, the following values are relevant to reliability coefficients: $0.40 \leq \alpha \leq 0.60$, $0.60 \leq \alpha \leq 0.80$, the scale is highly reliable, $0.80 \leq \alpha \leq 1.00$, the scale is highly reliable [88–90].

2.2.1.2. Factor analysis. Factor analysis is a data reduction and analysis method. Tabachnick and Fidell [91] argue that factor analysis produces a unique theoretical solution. There are two main approaches to factor analysis: exploratory factor analysis and confirmatory factor analysis. Exploratory factor analysis is used to obtain information about the relationships between variables. Exploratory factor analysis was used in this study. For exploratory factor analysis, it is considered sufficient for the correlation matrix to be greater than 0.3 for the strength of the relationships between variables. The two tests used to verify both conditions are Kaiser-Meyer-Olkin (KMO) sampling adequacy and Bartlett's test of sphericity. To understand the importance of a factor, the key variables belonging to each factor are identified and used as explanatory indicators. These key variables are selected according to four parameters: (1) the eigenvalue should be 1, (2) the loading values of the variables should be at least 0.4, (3) a variable should load on only one factor, and (4) a factor should include at least two variables [92].

2.2.2. Finding

The Cronbach's Alpha coefficients (α) for the 43 barriers to sustainable construction and the 40 drivers of sustainable construction scale were 0.909 and 0.918, respectively. Both coefficients exceeded the minimum threshold of 0.7, indicating high internal consistency among responses. This suggests that the

Table 3. Cronbach's alpha, mean, and standard deviation values of variables.

Variables	Cronbach alfa	Number of items	Mean	Standard deviation
Factors of sustainable construction	0.940	83	3.63	0.402
Barriers to sustainable construction	0.909	43	3.69	0.457
Drives of sustainable construction	0.918	40	3.56	0.495

Table 4. Results of factor analysis: Barriers to SC.

		Means and ranking of stressors				Exploratory Factor Analyse			
Factor	Code of drivers	Mean	SD	Overall IRI	Rank	Factor loadings (EFA)	% of variance	Cronbach Alpha	Cronbach's Alpha if the item is deleted
Factor 1	E21	3.49	0.930	0.693		0.742	11.47	0.809	0.764
	E22	3.76	1.107	0.749		0.631			0.779
	E20	3.40	0.987	0.676		0.627			0.783
	E35	3.91	1.022	0.735		0.593			0.783
	E33	4.21	1.040	0.681		0.573			0.783
	E34	3.45	0.940	0.778		0.522			0.790
	E10	3.65	0.928	0.724		0.515			0.796
Factor 2	E1	3.74	0.892	0.743		0.752	9.55	0.793	0.757
	E26	3.82	0.910	0.803		0.701			0.754
	E2	3.73	1.057	0.738		0.669			0.776
	E5	3.97	0.896	0.788		0.66			0.780
	E4	3.78	0.890	0.750		0.601			0.798
	E27	3.77	0.975	0.763		0.501			0.793
Factor 3	E30	3.73	0.913	0.740		0.676	7.90	0.727	0.659
	E31	3.86	0.934	0.761		0.629			0.668
	E37	3.83	0.912	0.766		0.624			0.677
	E32	4.02	0.744	0.772		0.604			0.681
	E38	3.87	0.955	0.740		0.434			0.716
Factor 4	E11	3.72	0.906	0.735		0.756	6.65	0.692	-
	E12	3.64	0.814	0.722		0.736			-
Factor 5	E15	3.38	1.059	0.671		0.829	6.36	0.779	-
	E16	3.42	0.964	0.678		0.781			-
Factor 6	E23	3.75	1.067	0.746		0.763	6.21	0.686	0.579
	E8	3.81	0.934	0.757		0.586			0.618
	E3	3.79	1.010	0.750		0.511			0.577
Factor 7	E25	4.07	0.815	0.808		0.704	5.79	0.678	0.525
	E17	3.70	0.954	0.735		0.568			0.585
	E14	3.68	0.985	0.729		0.509			0.627
	E9	3.79	0.906	0.755		0.385			0.675
Factor 8	E18	3.61	0.916	0.721		0.724	5.44	0.589	-
	E19	3.72	0.962	0.747		0.542			-
Factor 9	E29	3.70	0.819	0.741		0.657	4.80	0.603	0.439
	E6	3.86	0.850	0.774		0.603			0.437
	E28	3.70	0.728	0.747		0.404			0.566
							64.077		
	Kaiser-Meyer-Olkin (KMO) Value						0.802		
Barlett's Test of Sphericity				**Approx. Chi-Square**			1787.395		
				df:			561		
				p:			0.00		

responses given by the participants are highly reliable and consistent.

The 43 items assessing the most critical barriers to adopting sustainable construction practices were subjected to principal component analysis using SPSS 22. The results of the study are presented in Table 4. Before the exploratory factor analysis, the suitability of the data for the analysis was assessed. Examination of the correlation matrix showed that most of the coefficients were 0.3 and above. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.802 for barriers and 0.847 for drivers. This value is above the threshold of 0.5 [94]. Table 4 Barrtlett's test of sphericity is 1787. 395 ($p<0.05$) for barriers and 198, 413 (<0.05) for drivers. A Bartlett's test of sphericity was also performed, which is statistically significant ($p<0.05$) and indicates the appropriateness of the data. Kaiser-Meyer-Olkin (KMO) sampling adequacy value is 0.833 and exceeds the threshold value of 0.5, indicating that the data set is suitable for factor analysis, as Pallant [93] stated.

Nine barriers to sustainable construction factors with eigenvalues above one and explaining 80,2% of the total variance were identified. Comments, labels, and codes for each of these components are given below:

Factor 1 Uncertainties in the SC planning and implementation (E21, E22, E20, E35, E33, E34, E10)
Factor 2: Lack of knowledge and resistance to change by stakeholders regarding SC practices (E1, E26, E2, E5, E4, E27)

Table 5. Results of factor analysis: Drivers to SC.

Factor	Code of drivers	Means and ranking of stressors				Exploratory Factor Analyse		Cronbach Alpha	Cronbach's Alpha if the item is deleted
		Mean	SD	Overall IRI	Rank	Factor loadings (EFA)	% of variance		
Factor 1	G3	3.504	0.892	0.743		0.804	13.705	0.891	0.867
	G5	3.667	0.846	0.732		0.792			0.865
	G1	3.501	0.894	0.701		0.79			0.863
	G4	3.667	0.875	0.733		0.723			0.871
	G7	3.648	1.071	0.730		0.701			0.881
	G6	3.612	0.851	0.722		0.656			0.881
	G8	3.736	0.921	0.747		0.465			0.892
Factor 2	G30	3.473	0.907	0.695		0.745	10.464	0.833	0.806
	G33	3.512	1.057	0.702		0.709			0.796
	G29	3.496	0.905	0.699		0.677			0.803
	G32	3.326	0.851	0.665		0.663			0.810
	G31	3.628	0.961	0.726		0.636			0.805
	G28	3.636	0.758	0.727		0.537			0.819
Factor 3	G38	3.641	0.989	0.730		0.777	9.913	0.798	0.742
	G37	3.667	0.920	0.733		0.731			0.753
	G35	3.713	1.001	0.743		0.676			0.741
	G36	3.620	0.879	0.724		0.611			0.786
	G34	3.589	0.937	0.718		0.517			0.776
Factor 4	G12	3.744	0.895	0.749		0.722	8.755	0.727	0.588
	G15	3.636	1.088	0.727		0.687			0.737
	G11	3.651	0.920	0.730		0.603			0.656
	G10	3.876	0.929	0.775		0.558			0.672
Factor 5	G39	3.636	0.850	0.727		0.647	5.971	0.655	0.568
	G19	3.798	0.972	0.760		0.596			0.581
	G9	3.783	0.903	0.757		0.474			0.595
	G40	3.643	0.867	0.729		0.463			0.606
Factor 6	G17	3.682	0.961	0.736		0.807	5.885	0.635	0.575
	G16	3.550	0.987	0.710		0.530			0.388
	G18	3.760	0.914	0.752		0.490			0.631
Factor 7	G24	3.566	0.909	0.713		0.682	4.866	0.437	-
	G27	3.589	0.990	0.718		0.632			-
Factor 8	G14	3.767	0.983	0.753		0.641	4.663	0.602	-
	G13	3.651	0.944	0.730		0.511			-
	Total Explained Variance						64.222		
	Kaiser-Meyer-Olkin (KMO) Value						0.847		
Barlett's Test of Sphericity				**Approx. Chi-Square**			1981.413		
				df:			528		
				p:			0.00		

Factor 3: Lack of knowledge and training on sc materials, inadequate infrastructure (E30, E31, E37, E32, E38)
Factor 4 Contractual problems arising from uncertainties regarding SC practices (E11, E12)
Factor 5: Difficulties in implementing the SC international standards and certification system (E15, E16)
Factor 6: Inadequate awareness about the SC (E23, E8, E3)
Factor 7: Uncertainty about SC costs, insufficient investment incentives, lack of specialisation (E25, E17, E14, E9)
Factor 8: Inadequacy of legal regulations and sanctions related to SC (E18, E19)
Factor 9 Uncertainty about the strength of SC materials (E29, E6, E28)

Before the exploratory factor analysis, the suitability of the data for the study was evaluated. Kaiser-Meyer-Olkin (KMO) sampling adequacy measure was 0.802 for barriers and 0.847 for drivers. This value is above the threshold of 0.5 [94]—Table 5. Bartlett's test of sphericity is 1787. 395 ($p<0.05$) for barriers and 1981, 413 ($p<0.05$) for drivers. A Bartlett's test of sphericity was also performed, which is statistically significant ($p<0.05$) and indicates the appropriateness of the data. Kaiser-Meyer-Olkin (KMO) sampling adequacy value is 0.833 and exceeds the threshold value of 0.5, indicating that the data set is suitable for factor analysis, as Pallant [93] stated.

Eight drivers to sustainable construction factors with eigenvalues above one and explaining 84-7% of the total variance were identified. Comments, labels, and codes for each of these components are given below:

Factor 1: Environmental impacts of SY applications and increasing user comfort (G3, G5, G1, G4, G7, G6, G8)
Factor 2 Effects of Certification on Performance, Cost, and Competitiveness in Sustainable Buildings (G30, G33, G29, G32, G31, G28)
Factor 3 EM practices provide operational savings, return on investment, and increased asset value (G38, G37, G35, G36, G34)
Factor 4 Motivation of SY applications towards Energy Efficiency and Environmentally Friendly Products (G12, G15, G11, G10)
Factor 5: Increased competence of professionals regarding EM practices (G39, G19, G9, G40)
Factor 6: Sustainable Asset Building and Development of Corporate Culture (G17, G16, G18)
Factor 7: Government Policies and Technological Innovation (G24, G27)
Factor 8: Education and Experience and Setting Standards for Future Designs (G14, G13)

3. Conclusion

Several barriers prevent successful SC practice in the construction industry. Determining the drivers of SC practices will benefit stakeholders in the industry. This study identifies the barriers and drivers encountered in SC practice in the Turkish construction industry. The study's findings, obtained through a questionnaire survey, identify nine barriers and eight driver factors.

The study's findings indicate that SC planning and implementation uncertainties are the most critical barriers in Turkish construction industry SC practices. This finding suggests that professionals perceive implementation processes of SC projects to be uncertain, which can result in difficulties in time planning and realistically determining project duration. This, in turn, can lead to delays in project execution. In addition, studies have emphasised that SC practices may require additional time for sustainability measures [45, 95]. Furthermore, the findings show that SC may cause difficulties in time estimations due to problems in green material storage and long material procurement times.

The study identified two key barriers impeding the adoption of sustainable construction (SC) in the Turkish construction industry*: a lack of knowledge and training on SC materials and inadequate infrastructure*. The findings suggest that the cost of green materials and the time required to implement sustainable practices are practical barriers to the adoption of SC. In a similar finding, Tokbolat et al. [45] determined that two of the five most common barriers to adopting sustainable construction in Kazakhstan are related to cost. The study also demonstrates that the limited local production of green materials for SC, the need for extra time for sustainability measures, and the perception that sustainable materials are inadequate are barriers for professionals to adopt SC practices. In addition, Oke et al. [96] have argued that the lack of historical data and prototypes from which construction stakeholders can learn and build upon is a significant barrier.

In addition, the study identified the *uncertainty about the strength of the SC material* factor as a significant impediment within the study's context. This finding suggests that professionals perceive uncertainty regarding the durability of green materials, inadequate sample applications related to sustainable construction, and insufficient experience as the primary barriers, in addition to green material supply problems. Tokbolat et al. [45] also identified results consistent with this study's findings. The researchers determined that insufficient knowledge on green materials and technologies, insistence on using conventional methods of the traditional building production process, resistance to change, and insufficient knowledge of project participants (architect/engineer) on SC constitute barriers.

The study's findings demonstrate the efficacy of the factor *practices, which provide operational savings, return on investment, and increased asset value*. Darko et al. [38] argue that green buildings can have a lower life cycle cost due to lower energy bills through energy efficiency. Tokbolat et al. [45] found that sustainable construction contributes to energy and material efficiency and thus reduces building life cycle costs.

Djokoto et al. [28] argued in their study that some barriers to SC adoption are attributed to construction professionals because they are responsible for the delivery of construction projects. The labour force is the backbone of every industry; therefore, it is necessary to involve knowledgeable and able professionals who can promote sustainable construction [28]. The study's findings indicate that stakeholders' lack of knowledge and resistance to change *regarding SC Practices* is a significant barrier to SC adoption. This factor underscores the crucial role of awareness about the distinctions between SC and traditional building production processes in addressing this challenge. In addition, Rydin et al. [97] found that factors such as a lack of expertise or training, a lack of awareness, inexperience, and limited knowledge about sustainable construction project management were also significant. Häkkinen and Belloni [48] argued that a lack of knowledge or information about sustainability is a substantial barrier to SC. Furthermore, the study revealed that a lack of cooperation between stakeholders (architects, engineers, contractors, clients, etc.) regarding SC practices is a significant barrier.

Blayse and Manley [98] argued in their study that the construction industry has a weak response rate to change and innovation. Andelin et al. [51] argued that since investors are not interested in sustainability and developers do not want sustainable buildings, builders are unwilling to build them. The challenges identified in this study include using unfamiliar and inexperienced techniques, the necessity for additional testing and inspection in construction in SC applications, and the absence of manufacturer and supplier support and knowledge on performance. These findings indicate that the fear of SC transition is one of the significant challenges faced in the Turkish construction industry and many other countries [99].

The impact of financial difficulties on SC implementation is well-documented, with numerous studies conducted. The present study identified that *uncertainty about SC costs, insufficient investment incentives, and lack of specialization are* among the barriers to adopting SC practice. The study found that cost estimation is challenging due to the absence of data on SC costs, the potential for high investment costs, and the fact that investment returns may only be realised over time. In addition, Häkkinen and Belloni [48] argue that concerns regarding the cost disparity between SC and traditional construction methods and the unpredictability of costs are commonly cited as barriers to SC practice. Moreover, the study's findings indicate that variable customer demands and requests, in conjunction with a paucity of experts in SC practice, serve as impediments. These findings suggest that the acceleration of SC applications may be enhanced by establishing a supply-demand equilibrium. From this standpoint, providing low-interest credit opportunities to customers/users and investors will likely drive SC practices. Furthermore, government policies and suitable standards and procedures will enhance the appeal of SC practices. The findings of the research study corroborate this assertion. The results indicate that government policies and technological innovation are significant driving forces for adopting SC practices within the Turkish construction industry.

Babalola and Harinarain [52] argue in their study that government policies support sustainable construction and energy saving, considering the effects of construction on citizens' quality of life. Furthermore, the study indicates that government regulations significantly impact innovation adoption. In their research on construction projects in Ghana, Opoku et al. [100] determine that government policies and regulations are essential for environmental sustainability. Hai [101] argued that governments are responsible for formulating action plans and establishing legal frameworks to encourage implementing appropriate standards and procedures to facilitate subsequent measurement of implementation and performance.

The government establishes environmental regulations for each industry. Yet, the absence of comprehensive legislation and policies impedes the adoption of SC practices in the Nigerian real estate development industry. The implementation, compliance, and performance of building codes are measured and achieved to support the implementation of the building code through certifications such as energy performance certificates, supportive building control, positive labeling for buildings beyond the minimum building control level, energy offsets, and green certificates [52].

The findings of this study demonstrate that the inadequacy of legal sanctions for SC practices, the absence of specific regulations (laws, rules) for SY, and the *inadequacy of legal regulations and sanctions related to the SC* factor are significant barriers to SC practices. Sustainable construction is achieving sustainable construction is best achieved through government support and regulatory frameworks, given the fact that the government is not only a major customer of the construction industry but also can promote sustainable construction practices through grants and subsidies as incentives for adoption [38, 59].

The study's findings indicate that one of the primary impediments to SC is the *contractual issues arising from uncertainty regarding SC practices*. The rationale behind the efficacy of this element in SC practices can be attributed to the deficiencies inherent in contracts and the subsequent emergence of conflicts and disputes, precipitated by the uncertain nature of the implementation processes associated with SC projects. *Inadequate awareness about the SC, the idea that SC applications will not cover investment costs, insufficient knowledge of standards relating to SC applications, and the* complexity of SC application procedures. All these studies from developing countries agree that cost is the main barrier to implementing sustainable construction. Similarly, Williams and Dair [102] identified a lack of demand as the main barrier. This may be due to a lack of environmental concern, customer demand for sustainable buildings [103], and awareness of the benefits of sustainable construction. Construction professionals and the general public should be made to understand and realise the benefits of an improved built environment, as it is safer for nature and citizens in general [15].

Another study finding is that *difficulties in implementing the sc international standards and certification* *system* are one of the main barriers to SC practices. However, the optional execution of building standards constitutes a barrier to SC practices since it is not mandated by law [3]. The study's findings on *sustainable asset building and development of organizational culture* as a significant motivator suggest that, despite the often-overlooked role of culture in SC practices, government support emerges as a particularly effective technique to encourage SC practices due to its focus on tangible outcomes [104]. The culture of a region is determined by specific factors, such as climate, but also by factors such as common materials, availability of technologies, and social factors [105]. This study proposes government support as a moderator because the government can also advance the sustainable construction agenda through various policies, including financial support, legislation, standards, and building labelling with energy efficiency ratings [19; 106].

According to the study's results, *the environmental impacts of sc applications and increasing user comfort are the most important motivating factors* for SC in the Turkish construction industry. The reduction of environmental impact is supported by factors such as increased environmental awareness, social responsibility, and a sense of duty towards the environment, increased sensitivity towards the protection of natural resources/minimisation of losses, improved environmental quality/reduction of waste and CO2 emissions/improvement of water quality. In almost all studies, the environment is one of the most important and decisive factors for sustainable construction [2, 50]. *Motivation of SC applications towards Energy Efficiency and Environmentally Friendly Products*; need for efficient energy use/high energy efficiency, customer interest in environmentally friendly products/materials, positive contribution to corporate image/improvement of corporate image, protection of natural resources. According to Doonan et al. [107], this demand for green products and services is becoming one of the most critical factors driving the adoption of sustainability.

The findings indicate the efficacy of *education, experience, and setting standards for future designs*. These findings demonstrate that capabilities can be gained by ensuring coordination between academia and the industry and opening courses for SC in the curricula of academic institutions. Ayalp and Metinal [23, 65] highlight the paucity of SC-related curricula in architecture and engineering departments as a significant impediment. At the same time, Ofori [17] underscores the manifold challenges in developing countries, ranging from the formulation and delivery of professional training curricula to the involvement of institutions and the private and public industries. Aghimien et al. [27] emphasise the necessity for enhanced education and training in sustainable construction practices, while concurrently highlighting that *increased competence of professionals regarding SC practices* is a pivotal driver. Bamgbade et al. [74] underscore the significance of materials and human resources for construction firms, asserting that this is because activities in the construction industry are predicated on resources such as assets and human skills. From this standpoint, it was highlighted that construction firms may require strategic resources (in this context, organisational culture) to compete advantageously in delivering sustainable construction within the industry, as this is a significant source of competitive advantage for firms. Darko et al. [38] contend that environmentally friendly, green construction practices enhance environmental performance and social welfare, enabling firms to thrive economically. Bukarika and Robić [108] studied the impact of energy efficiency practices on enhancing corporate image. Kuosmanen and Kuosmanen [109] advanced the concept of sustainability as a pivotal factor in the success of business enterprises. They contended that sustainability is crucial in mitigating business risks and augmenting market opportunities for these enterprises.

The study results of certification's effects *on performance, cost, and competitiveness in sustainable buildings* demonstrate that it is an effective factor. The determination of performance measurement criteria with accreditation, the certification of quality parameters such as the certification system, indoor comfort, the reduction of life cycle cost, ease of marketing, advantage, product, and competitiveness are expected to increase. With the increasing population and the development of technology, energy demand is increasing day by day. This situation causes an increase in fossil resource consumption. It takes many years to reproduce the fossil resources that have been consumed. The need to leave a livable environment to future generations is mentioned in the Brundtland Common Future Report.

The impact of buildings on energy consumption is relatively high. For this reason, the importance of sustainability in building design is undeniable. This study conducted a field study on the barriers and drivers of sustainable building construction. Within the scope of the study, a survey was conducted on architects, engineers, contractors, and practitioners working in the building industry. The survey investigates the knowledge of industry stakeholders on sustainable construction and the reasons for preferring or not.

According to the survey, sustainable buildings increase user comfort in the interior and increase competition. In addition, although the initial construction cost of sustainable construction is high, its long-term profitability is undeniable. Sustainable buildings are energy efficient and environmentally friendly, requiring less energy than traditional buildings while providing indoor comfort. On the other hand, it is concluded that training people working in the construction industry on sustainable construction is insufficient, and training and certification systems should be developed in this regard. Future studies may focus on how sustainable building can be standardised according to regional conditions and how it can perform in future weather scenarios.

Conflict of interest

None.

Data availability statement

None.

Author's contributions

None.

References

1. Pickett STA, Cadenasso ML, Grove JM, Boone CG, Groman PM, Irwin E, Kaushal SS, Marshall V, McGrath BP, Nilon CH, Pouyat RV, Szlavecz K, Troy A, Warren P. Urban Ecological Systems: Scientific Foundations and A Decade of Progress. *Journal of Environmental Management*. 2011;92(3):331–62.
2. Zulu SL, Zulu E, Chabala M, Chunda N. Drivers and Barriers to Sustainability Practices in The Zambian Construction Industry. *International Journal of Construction Management*. 2023;23(12):2116–25. https://doi.org/10.1080/15623599.2022.2045425.
3. Aigbavboa C, Ohiomah I, Zwane T. Sustainable Construction Practices: "A Lazy View" of Construction Professionals in The South Africa Construction Industry. *Energy Procedia*. 2017;105:3003–10.
4. Badi S, Murtagh N. Green Supply Chain Management in Construction: A Systematic Literature Review and Future Research Agenda. *Journal of Cleaner Production*. 2019;223(20):312–22. https://doi.org/10.1016/j.jclepro.2019.03.132.
5. Bruntland G. Our common future. *The World Commission on Environment and Development*. 1987:45–65.
6. Bozkurt Y, Efe F. Sürdürülebilir Kalkinma ve Yeşil Ekonomik Büyüme Açısından Çevrenin Sürdürülebilirliğine Eleştirel Yaklaşim. *Dumlupınar Üniversitesi İİbf Dergisi*. 2024;13:12–25.
7. Toriola-Coker LO, Alaka H, Bello WA, Ajayi S, Adeniyi A, Olopade SO. Sustainability Barriers in Nigeria Construction Practice. In IOP Conference Series: Materials Science and Engineering. IOP Publishing, 2021.
8. Omopariola ED, Albert I, Windapo A. Appropriate Drivers for Sustainable Construction Practices on Construction Sites in Nigeria. In Proceedings of the 10th West Africa Built Environment Research (WABER) Conference (5–7), 2019.
9. Hoşkara E, Sey Y. Ülkesel Koşullar Bağlamında Sürdürülebilir Yapım. *Mimarlık, Planlama, Tasarım İTÜ Dergisi*. 2008;7:50–61.
10. Ruckelshaus WD. Toward A Sustainable World. *Scientific American*. 1989;261(3):166–75.
11. Ozmehmet DE. Dünyada ve Tükiye Sürdürülebilir Kalkınma Yaklaşımları. *Yaşar Üniversitesi E-Dergisi*. 2008;3(12):1853–76. https://doi.org/10.19168/Jyu.48930.
12. https://wwwcontextorg/about/who-weare/robertgilman/articles/.
13. Pierce LL. Barriers to Access: Frustrations of People Who Use A Wheelchair for Full-Time Mobility. *Rehabilitation Nursing Journal*. 1998;23(3):120–5.
14. Pamuk R, Kuruoğlu M. İnşaat Sektöründe Sürdürülebilirlik ve Bina İnşaatlarinda Evrensel Uygulama Örnekleri. *Beykent Üniversitesi Fen Ve Mühendislik Bilimleri Dergisi*. 2016;9(1).
15. Miranda L, Marulanda L. Sustainable Construction in Developing Countries-A Peruvian Perspective. *Agenda*. 2001;21.
16. Enshassi A, Mayer PE. Barriers to the application of sustainable construction concepts in Palestine. In Proceedings of the 2005 World Sustainable Building Conference, Tokyo, Japan. 2005.
17. Ofori G. Construction in Developing Countries. *Construction Management and Economics*. 2007;25(1):1–6.
18. Durdyev S, Ismail S, Bakar NA. Factors Causing Cost Overruns in Construction of Residential Projects: Case Study of Turkey. *International Journal of Science and Management*. 2012;1(1):3–12.
19. Pitt A. Misconceptions, Student Experience and Barriers to Learning: An Autoethnographic Study into Student Experience and Lecturer Perspectives. In Iceri 2015 Proceedings. Iated, 2015.
20. Osuizugbo IC. Disruptions And Responses Within Nigeria Construction Industry Amid COVID-19 Threat. *Covenant Journal of Research in the Built Environment*. 2020.
21. Ametepey O, Aigbavboa C, Ansah K. Barriers to Successful Implementation of Sustainable Construction in The Ghanaian Construction Industry. *Procedia Manufacturing*. 2015;3:1682–9.
22. Sabbagh MJ, Mansour OE, Banawi AA. Grease the green wheels: a framework for expediting the green building movement in the Arab world. *Sustainability (Switzerland)*. 2019;11(20):5545. doi:10.3390/su11205545.
23. Ayalp G, Metinal YB. Identifying Challenges Aecting Sustainable Construction in the construction Industry. *Proceedings of International Structural Engineering and Construction*. 2024;11(2).
24. Shen W, Tang W, Siripanan A, Lei Z, Duffield CF, Hui FKP. Understanding The Green Technical Capabilities and Barriers to Green Buildings in Developing Countries: A Case Study of Thailand. *Sustainability*. 2018;10(10):3585.
25. Mosly I. Safety Performance in The Construction Industry of Saudi Arabia. *International Journal of Construction Engineering and Management*. 2015;4(6):238–47.
26. Darko A, Chan AP. Critical Analysis of Green Building Research Trend in Construction Journals. *Habitat International*. 2016;57:53–63.
27. Aghimien DO, Oke AE, Aigbavboa CO, Thwala WD. Microscoping The Challenges of Sustainable Construction in Developing. *Journal of Engineering, Design and Technology*. 2019;17(6):1110–288. https://doi.org/10.1108/JEDT-01-2019-0002.

28. Djokoto SD, Dadzie J, Ohemeng-Ababio E. Barriers to Sustainable Construction in the Ghanaian Construction Industry: Consultants Perspectives. *Journal of Sustainable Development*. 2014;7(1):134–43. doi:10.5539/jsd.v7n1p134.
29. Martek I, Hosseini MR, Shrestha A, Zavadskas EK, Seaton S. The Sustainability Narrative in Contemporary Architecture: Falling Short of Building A Sustainable Future. *Sustainability*. 2018;10(4):981.
30. Xie M, Yangzi Q, Liang Y, Zhou Y, Liu Z, Zhang G. Policies, Applications, Barriers and Future Trends of Building Information Modeling Technology For Building. *Sustainability and Informatization in China*. 2022;8(2):7107–26. doi:10.1016/j.egyr.2022.05.008.
31. Park J, Tucker R. Overcoming Barriers to The Reuse of Construction Waste Material in Australia: A Review of The Literature. *International Journal of Construction Management*. 2017;17(3):228–37.
32. Banihashemi SA, Khalilzadeh M, Antucheviciene J, Edalatpanah SA. Identifying and Prioritising The Challenges and Obstacles of The Green Supply Chain Management in The Construction Industry Using The Fuzzy BWM Method. *Buildings*. 2023;13(1):38.
33. Omer MAB, Noguchi T. A Conceptual Framework for Understanding The Contribution of Building Materials in The Achievement of Sustainable Development Goals. *Sustainable Cities and Society*. 2020;52:2–4. https://doi.org/10.1016/j.scs.2019.101869.
34. Zuo J, Xia B, Chen Q, Pullen S, Skitmore M. Green building rating for office buildings: lessons learned. *Journal of Green Building*. 2016;11(2):131–46.
35. Naik TR, Moriconi G. Environmental Friendly Durable Concrete Made with Recycled Materials for Sustainable Concrete Construction. Proceedings of International Symposium on Sustainable Development of Cement, Concrete and Concrete Structures, 5–7 October 2005, Toronto, 2005. p. 485–505.
36. Liu X, Yang J, Qu S, Wang L, Shishime T, Bao C. Sustainable Production: Practices and Determinant Factors of Green Supply Chain Management of Chinese Companies. *Business Strategy and the Environment*. 2012;21(1):1–6.
37. Polat G, Turkoglu H, Gurgun AP. Identification of Material-related Risks in Green Buildings. *Procedia Engineering*. 2017;196:956–63. https://doi.org/10.1016/j.proeng.2017.08.036.
38. Darko A, Chan APC, Ameyaw EE, He BJ, Olanipekun AO. Examining Issues Influencing Green Building Technologies Adoption: The United States Green Building Experts' Perspectives. *Energy and Buildings*. 2017;144:320–32. https://doi.org/10.1016/j.enbuild.2017.03.060.
39. Du Q, Shao L, Zhou J, Huang N, Bao T, Hao C. Dynamics and scenarios of carbon emissions in China's construction industry. *Sustainable Cities and Society*. 2019;48:1–15. https://doi.org/10.1016/j.scs.2019.101556du.
40. Zuo J, Pullen S, Rameezdeen R, Bennetts H, Wang Y, Mao G, Zhou Z, Du H, Duan H. Green Building Evaluation From A Life-Cycle Perspective in Australia: A Critical Review. *Renewable and Sustainable Energy Reviews*. 2017;70:358–68. https://doi.org/10.1016/j.rser.2016.11.251.2012.
41. Dalirazar S, Sabzi Z. Strategic Analysis of Barriers and Solutions to Development of Sustainable Buildings Using PESTLE Technique. *International Journal of Construction Management*. 2023;23(1):167–81. doi:10.1080/15623599.2020.1854931.
42. Davies IEE, Davies OOA, Davies RM. The Impact of Green Buildings on the Development of a Sustainable Environment in Nigeria. *International Journal of Housing and Human Settlement Planning*. 2024;10(2). doi:10.37628/IJHHSP.
43. Karisma DA, Fatayana DI, Indrawan BD. Cementless Plastic Paving Block Innovation For Environmentally Friendly Pedestrian Area Utilization. In The Fourth International Conference on Government Education Management and Tourism, 2025. 4: p. 101–101.
44. Manoj T, Sai VS, Prasad DR, Tadepalli T, Rao TM, Bommisetty J. IoT-Driven Innovations in Concrete Curing: Advancing Sustainable Construction with Hot Water Curing. In E3S Web of Conferences 616, 03036. EDP Sciences, 2025.
45. Tokbolat S, Karaca F, Durdyev S, Calay RK. Construction Professionals–Perspectives on Drivers and Barriers of Sustainable Construction Environment. *Development and Sustainability*. 2020;22:4361–78. https://doi.org/10.1007/s10668-019-00388.
46. Çivici T, Özlük R. Potential Barriers to Sustainable Construction: A Model Proposal. *Journal of Sustainable Construction Materials and Technologies*. 2020;5(2):440–9. https://doi.org/10.29187/jscmt.2020.48.
47. Cobbinah PB, Erdiaw-Kwasie MO, Amoateng P. Rethinking sustainable development within the framework of poverty and urbanisation in developing countries. *Environmental Development*. 2015;13:15–8. https://doi.org/10.1016/j.envdev.2014.11.001015.
48. Häkkinen T, Belloni K. Barriers and Drivers For Sustainable Building Building Research And Information. *Building Research and Information*. 2011;39(3):239–55. https://doi.org/10.1080/09613218.2011.561948.
49. Ogungbile AJ, Oke AE. Sustainable construction practices in West African countries in Motoasca, E., Agarwal, A. and Breesch, H. (Eds), Energy Sustainability in Built and Urban Environments. Energy, Environment, and Sustainability, Springer, Singapore, 2019. doi:10.1007/978981-13-3284-5_1.
50. Akindele OE, Ajayi S, Toriola-Coker L, Oyegoke AS, Alaka H, Zulu SL. Sustainable Construction Practice in Nigeria: Barriers and Strategies for Improvement. *Built Environment Project and Asset Management*. 2023;13(4):590. https://doi.org/10.1108/BEPAM-06-2022-0085.
51. Andelin M, Sarasoja AL, Ventovuori T, Junnila S. Breaking The Circle of Blame for Sustainable Buildings-Evidence From Nordic Countries. *Journal of Corporate Real Estate*. 2015;17(1):26–5.
52. Babalola A, Harinarain N. Policy Barriers to Sustainable Construction Practice in The Nigerian Construction Industry: An Exploratory Factor Analysis. *Journal of Engineering, Design and Technology*. 2024;22(1):214–34. https://doi.org/10.1108/JEDT-07-2021-0375.
53. Du Plessis C. A Strategic Framework for Sustainable Construction in Developing Countries. *Construction Management and Economics*. 2007;25:67–6. https://doi.org/10.1080/01446190600601313.
54. Zainul-Abidin N. Investigating the Awareness and Application of Sustainable Construction Concept by Malaysian Developers. *Habitat International*. 2010;34(4):421–6. https://doi.org/10.1016/j.habitatint.2009.11.011.
55. Omopariola ED, Olanrewaju OI, Albert I, Oke AE, Ibiyemi SB. Sustainable Construction in the Nigerian Construction Industry: Unsustainable Practices, Barriers And Strategies. *Journal of Engineering, Design and Technology*. 2024;22(4):1158–84.
56. Tranfield D, Denyer D, Smart P. Towards A Methodology For Developing Evidence Informed Management Knowledge by Means of Systematic Review. 2003;14(3):207–22. doi:10.1111/1467-8551.00375.

57. Kitchenham B, Charters S. Guidelines for Performing Systematic Literature Reviews in Software Engineering. EBSE Technical Report EBSE-2007-012007, 2007.
58. Hwang BG, Shan M, Lye JM. Adoption of Sustainable Construction for Small Contractors: Major Barriers and Best Solutions. *Clean Technologies and Environmental Policy*. 2018;20(1):2223–37. https://doi.org/10.1016/j.ijproman.2012.05.004.
59. Adabre MA, Chan APC, Darko A, Osei-Kyei R, Abidoye R, Adjei-Kumi T. Critical Barriers to Sustainability Attainment in Aordable Housing: International Construction Professionals' Perspective. *Journal of Cleaner Production*. 2020;253(20). https://doi.org/10.1016/j.jclepro.2020.119995.
60. Rameezdeen R, Chileshe N, Hosseini MR, Lehmann S. Reverse logistics (RL) implementation among contractors in Australia: Practices and barriers. In A. B. Raiden & E. Aboagye-Nimo (Eds.), Proceedings of the 30th Annual ARCOM Conference, 2014. p. 83–92. Association of Researchers in Construction Management.
61. Amal A, Arif Mohammed A, Mohammad Asim Q. Barriers to Mnes Green Business Models in The UK Construction Sector: An ISM Analysis. *Journal of Cleaner Production*. 2017;160(27):371. https://doi.org/10.1016/j.jclepro.2017.01.003.
62. Jadidoleslami S, Saghatforoush E, Heravi A, Preece C. Evaluating the existing barriers in implementing constructability. *Civil Engineering Journal*. 2018;4(12):2901–12. https://doi.org/10.28991/cej-03091204.
63. Al-Raqeb H, Ghaar SH, Haitherali H, Gopakumar A. Overcoming Barriers to Implementing Building Information Modelling in Kuwait's Ministry of Public Works: A Framework for Sustainable Construction. *Buildings*. 2024;14(1):130. https://doi.org/10.3390/buildings14010130.
64. Dosumu O, Aigbavboa C. Adoption of light steel (LS) for building projects in South Africa. *Journal of Engineering, Design and Technology*. 2018;16(5):711–33. https://doi.org/10.1108/JEDT-04-2018-0075.
65. Ayalp G, Metinal YB. Identifyong Challenges Aecting Sustainable Construction in the Construction Industry. *Proceedings of International Structural Engineering and Construction*. 2024;11(2):AAE-12-2.
66. Wong SY, Low WW, Wong KS, Tai YH. Barriers for green building implementation in Malaysian construction industry. In IOP Conference Series: Materials Science and Engineering. IOP Publishing, 2021.
67. Zhang Q, Oo BL, Lim BTH. Key Practices and Impact Factors of Corporate Social Responsibility Implementation: Evidence from Construction Firms. *Engineering, Construction and Architectural Management*. 2023;30(5):2124–54. https://doi.org/10.1108/ECAM-11-2020-0973.
68. Pham H, Kim SY, Luu TV. Managerial Perceptions on Barriers to Sustainable Construction in Developing Countries: Vietnam Case. *Environment, Development and Sustainability*. 2020;22:2979–3003.
69. Marsh RJ, Brent AC, De Kock IH. An integrative review of the potential barriers to and drivers of adopting and implementing sustainable construction in South Africa. *South African Journal of Industrial Engineering*. 2020;31(3):1–15. https://doi.org/10.7166/31-3-2417.
70. Abidin NZ, Powmya A. Perceptions on Motivating Factors and Future Prospects of Green Construction in Oman. *Journal of Sustainable Development*. 2014;7(5):231. https://doi.org/10.5539/jsd.v7n5p231.
71. Negash YT, Hassan AM, Tseng ML, Wu KJ, Ali MH. Sustainable Construction and Demolition Waste Management in Somaliland: Regulatory Barriers Lead to Technical and Environmental Barriers. *Journal of Cleaner Production*. 2021;297:126717. https://doi.org/10.1016/j.jclepro.2021.126717.
72. Mohamed EH, Mohamed AZ. The Implementation of Building Information Modeling (BIM) Towards Sustainable Construction Industry in Egypt: The Pre-Construction Phase. *Journal of Building Engineering*. 2019;25:100828. https://doi.org/10.1016/j.jobe.2019.100828.
73. Kissa E, Sadick MA, Agyemang DY. Drivers Militating against the Pricing of Sustainable Construction Materials: The Ghanaian Quantity Surveyors Perspective. *Case Studies in Construction Materials*. 2018;8:507–16. https://doi.org/10.1016/j.cscm.2018.04.003.
74. Bamgbade JA, Nawi MNM, Kamaruddeen AM, Adeleke AQ, Salimon MG. Building Sustainability in The Construction Industry Through Firm Capabilities, Technology and Business Innovativeness: Empirical Evidence from Malaysia. *International Journal of Construction Management*. 2022;22(3):473. https://doi.org/10.1080/15623599.2019.1634666.
75. Okika MC, Okika MC, Vermeulen A, Pretorius JHC. Barriers to the implementation of sustainable construction practices in the South African construction industry. *Journal of Engineering, Design and Technology*. 2019;17(3):497–515. https://doi.org/10.1108/JEDT-10-2018-0192.
76. Borg R, Gonzi RD, Borg SP. Building Sustainably: A Pilot Study on The Project Manager's Contribution in Delivering Sustainable Construction Projects. A Maltese And International Perspective. *Sustainability (Switzerland)*. 2020;12(23):1–151. https://doi.org/10.3390/su122310162.
77. Bashir MT, Abdul Basit K, Md. Munir Hayet K, Kumeel R, Syed S, Faizan F. Evaluating the Implementation of Green Building Materials in the Construction Sector of Developing Nations. *Journal of Human, Earth, and Future*. 2024;5(3):528–42. https://doi.org/10.28991/HEF-2024-05-03-015.
78. De Oliveira JCF, Oliveira JCF, Coutinho De Melo FJ. Barriers and Drivers of Sustainable Construction: A Systematic Literature Review. *International Journal of Services and Operations Management*. 2023;47(3):277–313. https://doi.org/10.1504/IJSSOC.2023.131692.
79. Ahmad T, Thaheem MJ, Anwar A. Developing a Green-Building Design Approach By Selective Use of Systems And Techniques. *Architectural Engineering and Design Management*. 2016;12(1):29–50. https://doi.org/10.1080/17452007.2015.1095709.
80. Ahmed AM, Sayed W, Asran A, Nosier I. Identifying Barriers to the Implementation and Development of Sustainable Construction. *International Journal of Construction Management*. 2023;23(8):1277–88. https://doi.org/10.1080/15623599.2021.1967577.
81. Gamil Y, Abdullah MA, Abd Rahman I, Asad MM. Internet of things in construction industry revolution 4.0 Recent trends andchallenges in the Malaysian context. *Journal of Engineering, Design and Technology*. 2020;18(5):1091–102. https://doi.org/10.1108/JEDT-06-2019-0164.
82. Sharma G. Pros and cons of dierent sampling techniques. *International Journal of Applied Research*. 2017;3(7):749–52.
83. Enshassi A, Mayer PE. Barriers to the application of sustainable construction concepts in Palestine. World Sustainable Building Conference September 2005, Tokyo, 2005 p. 27–29.
84. Akintoye A, Mcintosh G, Fitzgerald F. A Survey of Supply Chain Collaboration and Management in the UK Construction Industry. *European Journal of Purchasing and Supply Management*. 2000;6:159–68. https://doi.org/10.1016/S0969-7012(00)00012-5.
85. Zhao ZY, Chen YL. Critical Factors Aecting the Development of Renewable Energy Power Generation: Evidence

from China. *Journal of Cleaner Production*. 2018;184:466–80. https://doi.org/10.1016/j.jclepro.2018.02.254.
86. El-Gohary KM, Aziz RF. Factors Influencing Construction Labor Productivity in Egypt. *Journal of Construction Engineering and Management*. 2013;139(1):1–9. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000168.
87. Cronbach LJ. Coefficient Alpha and The Internal Structure of Tests. *Psychometrika*. 1951;16(3):297–334.
88. Tavakol M, Dennick R. Making sense of Cronbach's alpha. *International journal of medical education*. 2011;2:53.
89. Nunnally JC, Bernstein IH. Psychometric Theory (3. Baskı). Mcgraw-Hill. 1994.
90. Özdamar K. Paket Programlar ile İstatistiksel Veri Analizi 1. Kaan Kitabevi, Eskişehir, 1999.
91. Tabachnick BG, Fidell LS. Using Multivariate Statistics. 5th ed. New York: Allyn and Bacon. 2007.
92. Gorsuch RL. Exploratory factor analysis. In Handbook of multivariate experimental psychology. Boston, MA: Springer US, 1988.
93. Pallant JF, Bailey CM. Assessment of The Structure of The Hospital Anxiety and Depression Scale in Musculoskeletal Patients. *Health and quality of life outcomes*. 2005;3:1–9.
94. Kaiser HF. An index of factorial simplicity. *Psychometrika*. 1974;39(1):31–6.
95. Akadiri PO, Chinyio EA, Olomolaiye PO. Design of A Sustainable Building: A Conceptual Framework For Implementing Sustainability in The Building Sector. *Buildings*. 2012;2(2):126–52. https://doi.org/10.3390/buildings2020126.
96. Oke A, Aghimien D, Aigbavboa C, Musengaa C. Drivers of Sustainable Construction Practices in the Zambian Construction Industry. Energy Procedia 158 (2019), 10th International Conference on Applied Energy (ICAE2018), August 22–25, 2018, Hong Kong, China.
97. Rydin H, Gunnarsson U, Sundberg S. The Role of Sabhagnum in Peatland Development and Persistence. 2006.
98. BlayseBlayse AM, Manley K. Key influences on construction innovation. *Construction Innovation*. 2004;4(3):143–54. https://doi.org/10.1108/14714170410815060.
99. Karji A, Namian M, Tafazzoli M. Identifying The Key Barriers to Promote Sustainable Construction in The United States: A Principal Component Analysis. *Sustainability (Switzerland)*. 2020;12(12):5088. https://doi.org/10.3390/su12125088.
100. Opoku DGJ, Ayarkwa J, Agyekum K. Barriers to environmental sustainability of construction projects. *Smart and Sustainable Built Environment*. 2019;8(4):292–306. https://doi.org/10.1108/SASBE-08-2018-0040.
101. Hai D. Process of public policy formulation in developing countries. Public Policy, pp. 1–12, available at: www.icpublicpolicy.org/IMG/pdf/panel_11_s1_hai_phu_do.pdf (accessed 23 February 2025).
102. Williams K, Dair C. What is Stopping Sustainable Building in England? Barriers Experienced By Stakeholders in Delivering Sustainable Developments. *Sustainable Development*. 2006;15(3):135–47.
103. Dalirazar S, Sabzi Z. Strategic Analysis of Barriers and Solutions to Development of Sustainable Buildings Using PESTLE Technique. *International Journal of Construction Management*. 2023;23(1):167–81. doi:10.1080/15623599.2020.1854931.
104. Samari M, Ghodrati N, Esmaeilifar R, Olfat P, Shafiei MWM. The Investigation of The Barriers in Developing Green Building in Malaysia Modern Applied Science. 2013;7(2): 1–12.
105. Rapoport A. House Form and Culture. University of Wisconsin Milwaukee Prentice Hall, Inc., Eglewood Clis, London, 1969.
106. Lazar N, Chithra KA. Comprehensive Literature Review on The Development of Building Sustainability Assessment Systems. *Journal of Building Engineering*. 2020;32. doi:10.1016/j.jobe.2020.101450.
107. Doonan J, Lanoie P, Laplante B. Determinants of environmental performance in the Canadian pulp and paper industry: An assessment from inside the industry. Ecological Economics, Elsevier, October. 2005. 55(1): p. 73–84.
108. Bukarica V, Robić S. Implementing energy efficiency policy in Croatia: stakeholder interactions for closing the gap. *Energy Policy*. 2013;61:414–22. doi:10.1016/j.enpol.2013.06.052.
109. Kuosmanen T, Kuosmanen N. How not to measure sustainable value (and how one might). *Ecological Economics*. 2009;69(2):235–43. https://doi.org/10.1016/j.ecolecon.2009.08.008.