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Critical Success Factors of Sustainability Implementation in the Construction Industry

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Abstract: Sustainability is one of the emerging areas in building construction, and it is widely investigated in terms of bringing sustainable technology into construction. However, one of the biggest challenges in the construction industry is implementing sustainability. Building contractors and construction practitioners mostly struggle with the implementation of sustainability due to the lack of certain parameters that define sustainability. Therefore, this study investigates the factors for effective sustainability implementation to provide industry practitioners with the benefit of the extensive list of parameters when designing their sustainability program. To research the parameters, a questionnaire was designed and administered to construction professionals with wide experience in sustainability implementation. The respondents were asked to evaluate a set of sustainability factors in the economic, social, and environmental domains. This way, the study provides reflections from construction practitioners working on large projects. The findings indicated that Ethical and Relational Factors in economic sustainability, Historical and Social Relations Factors in social sustainability, and Material Usage Factors in environmental sustainability are the most important for effective sustainability implementation. The findings are expected to help construction practitioners understand metrics of sustainability, effectively manage their projects, and successfully implement sustainability with the consideration of proper metrics.

Keywords: sustainability; implementation; building construction; factor analysis; critical success factors

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1. Introduction

The construction industry is reported to be one of the largest contributors to waste and pollution [1,2]. Buildings are indicated to be the main consumers of natural resources responsible for 40% of total CO_2 emissions and 30% of global raw material consumption [3]. Considering the impact of the construction industry on the natural environment and human health, it is critical that the industry develops sustainability standards for the protection of human well-being and the natural environment. The Brundtland Report defines sustainable construction as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [4]. Even though the efforts in sustainable construction are encouraging, the industry still lacks the expertise in becoming sustainable. This reveals that implementation programs for sustainability are neither well-understood nor vague for the practitioners. According to Presley et al. [5], having indicators for the integration of sustainability into project management practices ensures sustainable project success.

Previous studies investigated sustainability linked to business strategy [6] and sustainability critical success factors for better construction and project management practices [7,8]. However, there is still a lack of research in terms of providing the essential critical success factors for sustainability implementation in construction projects. The main contribution of this study is to provide a synthesis of the current efforts in sustainability and reveal the factors to be considered in implementing successful sustainable programs. The results of the study are expected to guide construction practitioners in applying wise strategies by considering the identified success factors.

This study aims to respond to the following research questions:

- What are the critical success factors of environmental sustainability and how are these factors emerging around sustainable construction?
- What are the critical success factors of social sustainability and how are these factors emerging around sustainable construction?
- What are the critical success factors of economic sustainability and how are these factors emerging around sustainable construction?

This study investigates what the critical success factors are that could help industry practitioners and policymakers in terms of implementing sustainable practices. The success factors were analyzed into three domains: social, environmental, and economic. The study first presents how the factors were developed as part of the research background. Then, the study presents the methodology. As part of the methodological approach, a questionnaire was first developed to measure the importance level of factors rated by the respondents. Then, the factors are analyzed with the factor analysis tool of SPSS software version 29.0. The study further presents the results and discusses the three pillars of sustainability in the success factors context and ratings of the respondents. Then, conclusions are presented reflecting both theoretical and practical applications.

2. Research Background

The expectations of the stakeholders in the construction industry have recently gained acceleration with the tightening of environmental regulations and increasing energy and waste costs. In particular, large companies in the sector focus on improving production capacity to achieve better performance and highlight responsibilities in sustainability [9]. However, sustainability has not yet been fully integrated or adopted in the construction industry [10]. According to some researchers, the main barriers to the adoption of sustainability stem from low sustainability awareness [11,12], lack of government support [12], high initial investment costs, customer attitude [12,13], lack of knowledge and standards, financial constraints, and poor design practices [10].

According to Babalola and Harinarain [14], a policy for sustainable construction should be established and critical stakeholders such as the government, finance providers, end users, and professionals should be involved in specified processes. The construction sector has been criticized in past years for not having a well-established sustainability development model [9]. Against these criticisms, the UK government published the "Sustainable Construction Strategy" report in 2008 to promote sustainable construction [9,15]. This report also shows that the UK government takes sustainable construction seriously and aims to lead the world in this field [10].

Today, several companies use a calculation system with three performance dimensions (environmental, social and economic performance) to calculate their sustainability performance [16]. With this three-dimensional analysis, the worldwide impact of corporate activities can be measured, and the foundations of sustainability can be determined. Additionally, this shows that sustainability is not just a management tool [17].

According to Liu et al. [18], sustainable construction should be evaluated in economic, social, and environmental systems. Some other researchers further imply that the social, economic, and environmental foundations of sustainability for sustainable development should be harmonious and balanced [19–21].

These fundamentals serve as a driver for sustainable construction, and at least one of these drivers must be simplified for the development of sustainable construction [22,23].

Social sustainability is achieved by establishing social standards in the construction industry, increasing the quality of life, and conducting social projects. The aim is to ensure close cooperation between customers, employees, suppliers, and other resources to increase customer satisfaction [18]. However, there is a considerable lack of research on social sustainability in the construction sector in the literature [24–28].

A considerable portion of the studies evaluated infrastructure projects in terms of social sustainability [26,29–32]. A group of studies further examined social sustainability in the construction sector [33–36]. According to Taherkhani [27], there is no comprehensive social sustainability framework to identify and measure social factors in buildings. Therefore, socio-environmental, socio-economic, socio-political, socio-cultural, and socio-institutional systems must be designed to create this framework [27]. According to Almahmoud and Doloi [25], social sustainability can be created in the neighborhood community formed by new construction thanks to social functions such as health, physical comfort, economy, accessibility, integration, and participation. In addition, there are studies in the literature investigating social sustainability in the fields of purchasing [37] (Marzouk and Sabbah, 2021), management [38], organizational culture [39], and highway [40,41] in the construction sector.

Construction is listed among the causes of many environmental problems such as excessive consumption of global resources and pollution of the environment. Today, research on green building design and the use of environmentally friendly building materials has increased to reduce negative environmental effects [42]. Some researchers have investigated BIM [43–45], green building techniques [46,47], and the use of waste materials techniques [48,49] to achieve environmental sustainability in the construction industry. According to Dobson et al. [9], although sustainability increases the cost of construction, the use of sustainable construction methods provides savings in carbon emissions and the operating costs of structures.

Economic sustainability in the construction industry has a variety of implementation opportunities. However, it has not yet been taken into consideration as other sustainability techniques [50]. Akotia and Sackey [51] conducted a study with the aim of ensuring socio-economic sustainability in renovation projects in the UK. The study showed that construction companies often promote socio-economic sustainability principles and integrate them into their business practices. In this way, companies aim to stay in the market environment and gain an advantage over their competitors. Alaloul et al. [50] evaluated economic sustainability in the US, China, and UK construction industries. The study showed that the construction sector could be sustainable by investing in work intensity. According to Alaloul et al. [50], work intensity is the only way to have energy- and resource-efficient processes, use the resource stock optimally, and ensure optimum workflow. Economic sustainability indicators in the selection of building materials are structural cost, non-construction cost, maintenance cost, and additional income [52].

Given this background, previous studies have failed to address the three pillars of sustainability in terms of sustainable construction. There is not yet comprehensive research investigating the critical success factors in terms of these three pillars, namely, the environmental, economic, and social. These three fundamental systems are the core components of sustainability and require special investigation. The integrated evaluation of environmental, economic, and social sustainability systems contributes to construction practitioners' holistic understanding of sustainability and to the development of their knowledge for guiding sustainable construction. Therefore, this study aims to reveal the success factors in these three domains by providing a clear roadmap for both researchers and industry practitioners in terms of devising strategies for sustainable construction.

3. Research Methodology

This study aims to investigate economic, social, and environmental sustainability CSFs in the construction industry. In this study, variables for environmental, economic, and social sustainability were identified through an in-depth literature review. Then, semi-structured interviews were conducted to assess the validity and reliability of the variables obtained through the literature review. The interviewees were selected based on their years of experience in sustainability implementation and the construction industry. A minimum of 5 years was sought in terms of sustainability experience and 10 years of experience in the construction industry were the inclusion criteria for the interviews. A total of 11 interviews were conducted with experts, and each interview took 30 min. The semi-structured interview method was chosen. The effectiveness of semi-structured interviews has already been mentioned in various studies [53,54]. Effective feedback was achieved from the interviewees, as the three pillars of sustainability were thoroughly discussed, and the factors affecting these pillars were further addressed.

After evaluating expert comments and suggestions, a comprehensive list of variables was created. In the initial stage, 21 variables were created for economic sustainability, while 17 variables for social and 21 variables for environmental sustainability were considered. However, after discussing with the experts, some variables were either merged or removed. In the final list, a total of 19 variables for environmental sustainability, 16 variables for social sustainability, and 18 variables for economic sustainability were identified. Then, an online survey was designed and recently administered to construction companies operating in the United States for questionnaire evaluation. The questionnaire method is common in several construction-related studies, and online questionnaires provide various advantages for anonymity, ease of data collection, and shorter data collection durations [55,56].

The questionnaire included questions regarding demographic information and ratings for the three pillars of sustainability. Stratified sampling was used to select the respondents. The inclusion criteria were to have at least 10 years of experience in the construction industry, along with 5 years of experience in sustainable project. The questionnaire was sent out to the respondents through online channels. Figure 1 presents the steps taken to conduct this study.

The list of factors is presented in Tables 1–3, along with relevant references. Then, an online questionnaire was designed using the factors in the list. The questionnaire consisted of two parts. In the first part, the questions aimed at gathering general information about the respondents and responding companies. In the second part, success factors were asked to be rated on a 5-point Likert scale in terms of their importance level in succeeding sustainability, where 1 represents very low importance and 5 represents very high importance. Questionnaires were sent to construction firms listed on Engineering News-Record's (ENR) 2019 Top Contractors List. From a total of 400 questionnaires, 101 responses were collected, with a 25% response rate. The questionnaire data were analyzed using the Factor Analysis tool of SPSS software version 29.0. In the factor analysis, the extraction method used was Principal Component Analysis, and the rotation method applied was Varimax. Factor analysis is a multivariate statistical method that reduces the number of variables to a few factors. In addition, this method also facilitates interpretation by rotating the factors [57].

Table 1 presents the variables of economic sustainability in the construction industry, along with the relevant references.

Table 2 presents the variables of social sustainability in the construction industry, along with the relevant references.

Table 3 presents the variables of environmental sustainability in the construction industry, along with the relevant references.

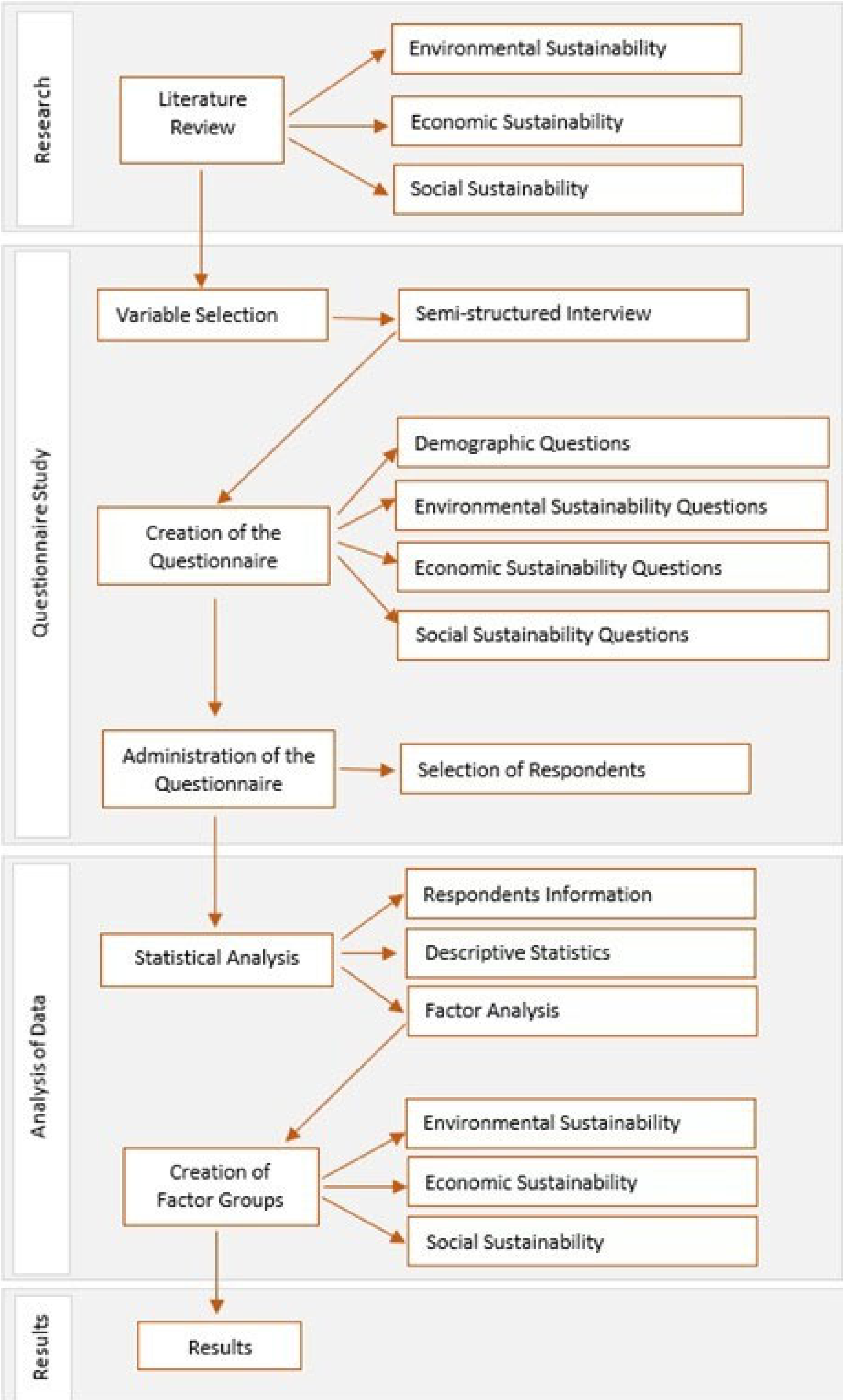

Figure 1. Research steps.

Table 1. Variables of economic sustainability for the construction industry.

	Innovation Management/New Product Development/Productivity and Flexibility	Stakeholder/Customer Engagement and Demand	Customer Relationship Management	Business Ethics and Moral Obligation	Cost Management Plan (Costs, Returns on Investment…)	Supply Relations, Chain Cooperation, and Integration	Contribution to Gross Domestic Product (GDP) (Economic Performance-Income and Employment)	Project Control and Management	Scope Control and Business Scope	Competitiveness and Growth	Organizational (Organization) Culture	Strategic Planning and Management	Quality and Management	Taxes and Tax Policy	End of Building Cost	Internal Rate of Return and Return on Investment, Capital Budget	Business Success/Financial Benefits of Practices	Internationalization
	Eco1	**Eco2**	**Eco3**	**Eco4**	**Eco5**	**Eco6**	**Eco7**	**Eco8**	**Eco9**	**Eco10**	**Eco11**	**Eco12**	**Eco13**	**Eco14**	**Eco15**	**Eco 16**	**Eco17**	**Eco18**
[58]	x					x												
[59]	x						x	x				x						
[60]	x														x			
[61]	x														x			
[62]	x				x								x					
[63]	x																	
[64]	x	x	x	x	x	x					x	x						
[65]	x																	x
[66]							x		x							x		
[52]														x	x			
[51]		x	x	x						x								
[67]		x		x														x
[68]		x	x															
[69]			x				x											
[70]					x													
[71]								x										
[72]									x									
[73]									x									
[74]										x				x		x		
[75]	x										x						x	
[76]	x	x	x	x	x						x						x	x
[77]					x					x								
[5]													x					

Table 2. Variables of social sustainability for the construction industry.

	Labor (Worker) Practices (Health, Safety, and Working Conditions, Education, and Training)	Supplier–Contractor Relationship	Stakeholder Involvement/Management	Cultural Heritage	Equality, Justice, and Ethical Behavior	Local Employment (Capacity)	User (Public) Safety and Health	Social Justice	User or Community Satisfaction	Public Participation and Compliance	Social Action Funding (Philanthropy and Corporate Citizenship, Government Social Projects, Leadership and Social Impact)	Communication Between Stakeholders	Social Integration	Environmental and Sustainability Awareness	Corporate Sustainability and Organizational Culture	Community/People's Needs Assessment and Improvement of Quality of Life
	Soc1	**Soc2**	**Soc3**	**Soc4**	**Soc5**	**Soc6**	**Soc7**	**Soc8**	**Soc9**	**Soc10**	**Soc11**	**Soc12**	**Soc134**	**Soc14**	**Soc15**	**Soc16**
[58]	x						x									
[59]	x		x	x			x	x	x	x			x	x		
[60]	x			x					x							
[61]	x			x					x							
[76]	x	x	x								x					
[62]	x		x													
[63]	x	x			x		x			x						
[64]	x	x	x					x			x				x	x
[75]	x											x			x	x
[36]	x		x	x	x	x						x				
[66]						x										
[69]		x														
[67]	x	x														
[78]				x					x	x				x		
[74]				x		x	x									
[77]					x			x								
[48]	x					x		x								
[79]													x			
[70]	x															

Table 3. Variables of environmental sustainability for the construction industry.

	Env1 Water Quality Impact And Consumption	Env2 Energy Consumption	Env3 Waste Generation and Management	Env4 Available Use of Suitable Renewable Energy Sources/Fossil Fuels	Env5 Soil (Land) Use and Ecological Value	Env6 Environmental Responsibility/Justice	Env7 Reducing Environmental Impacts by Considering the Life Cycle of Products and Services	Env8 Material Reusability (Potential That Structural Materials Can Be Reused for the Next Project)	Env9 Material Reduction, such as Using Recycled Materials and/or Reusing Structural Element	Env10 Material Consumption	Env11 Noise Pollution	Env12 Material Recyclability (Potential that Structural Materials can be Recycled for Future Use)	Env13 Environmental Management Systems/Policy Implications	Env14 Adaptation to Climate Change	Env15 Environmental Education and Training	Env16 Regional (Local) Material Use	Env17 Ecological Protection and Diversity	Env18 Water Recycling	Env19 Emission of Other Harmful Gases to the Atmosphere
[58]	x	x	x					x	x	x		x							
[66]	x		x				x	x			x	x					x		
[59]	x	x		x	x											x			x
[77]	x	x		x	x				x	x							x		
[60]	x		x	x					x							x			
[61]	x		x	x					x							x			
[76]	x	x				x	x						x						
[78]	x		x		x						x							x	
[62]	x						x												
[74]	x				x						x								
[63]	x	x	x					x										x	
[64]	x			x		x	x	x					x	x	x				
[68]	x	x		x						x									x
[65]	x	x			x			x		x				x					
[52]	x	x							x			x							
[69]		x			x														
[75]																			
[67]						x									x				
[80]	x				x			x				x				x		x	

4. Results

A total of 101 responses were collected, and data obtained through the questionnaire were used in the analysis. The characteristics of the questionnaire participants and the companies they work for are evaluated and shown in Table 4. Additionally, descriptive statistics were examined for the economic, social, and environmental sustainability variables determined by the literature review. Table 5 presents descriptive statistics for the economic, social, and environmental sustainability variables. Finally, factor analysis was conducted separately for each sustainability system. Five factor groups were obtained for each system, and their detailed information is shown in Tables 6–9.

Table 4. General information about the respondents and responding companies.

Categories			Percentage (%)
Respondents	Gender	Female	34.4
		Male	65.6
	Education	PhD	13.1
		MSc	65.6
		BSc	21.3
	Years of Experience	0–5 years	0.0
		6–10 years	13.1
		11–15 years	14.8
		16–20 years	27.9
		Above 20 years	44.3
	Current Role	Chairman	3.3
		Board Member	18.0
		General Manager	19.7
		Vice General Manager	3.3
		Project Coordinator	16.4
		Project Manager	16.4
		Department Chief	8.2
		Architect	6.6
		Engineer	4.9
		Facility Manager	3.3
		Technician	3.3
Responding Companies	Business Area	Infrastructure	65.6
		Residential	70.5
		Commercial	77.0
		Industrial	34.4
	Years of Operation	0–5 years	0.0
		6–10 years	0.0
		11–15 years	3.3
		16–20 years	19.7
		Above 20 years	77.0
	Annual Turnover	0–100 Million USD	18.0
		101–499 Million USD	39.3
		500–999 Million USD	21.3
		1000–1999 Million USD	16.4
		Above 2000 Million USD	4.9
	Number of Employees	0–100 people	13.3
		101–499 people	21.7
		500–999 people	38.3
		1000–1999 people	25.0
		Above 2000 people	1.7

Table 5. Descriptive statistics: Economic, social, and environmental sustainability for the construction industry.

Economic			Social			Environmental		
Variables	**Mean**	**Std. Deviation**	**Variables**	**Mean**	**Std. Deviation**	**Variables**	**Mean**	**Std. Deviation**
Eco1	4.0	0.5	Soc1	4.0	0.3	Env1	4.3	0.5
Eco2	3.6	0.5	Soc2	3.4	0.6	Env2	4.8	0.4
Eco3	3.7	0.6	Soc3	3.4	0.6	Env3	4.0	0.5
Eco4	3.6	0.5	Soc4	3.3	0.6	Env4	4.3	0.5
Eco5	4.3	0.5	Soc5	4.6	0.6	Env5	4.1	0.4
Eco6	3.7	0.6	Soc6	3.7	0.6	Env6	4.6	0.6
Eco7	4.2	0.5	Soc7	3.8	0.7	Env7	4.3	0.5
Eco8	4.3	0.5	Soc8	4.6	0.5	Env8	4.0	0.5
Eco9	3.8	0.5	Soc9	4.3	0.6	Env9	4.0	0.5
Eco10	4.0	0.5	Soc10	4.5	0.6	Env10	3.9	0.4
Eco11	3.6	0.5	Soc11	4.7	0.4	Env11	4.2	0.6
Eco12	3.7	0.6	Soc12	3.8	0.6	Env12	4.1	0.6
Eco13	3.5	0.6	Soc13	4.5	0.5	Env13	4.4	0.5
Eco14	3.6	0.5	Soc14	4.5	0.6	Env14	4.5	0.5
Eco16	3.9	0.5	Soc15	3.9	0.6	Env15	4.5	0.6
Eco17	4.4	0.5	Soc16	4.0	0.5	Env16	4.1	0.6
Eco18	4.1	0.4				Env17	4.2	0.5
Eco19	3.2	0.6				Env18	4.3	0.5
						Env19	4.3	0.5

Table 6. Total variance explained by economic, social, and environmental sustainability.

Component		Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
		Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
Economic	1	4.62	25.66	25.66	4.62	25.66	25.66	3.32	18.43	18.43
	2	2.52	13.99	39.64	2.52	13.99	39.64	2.31	12.83	31.26
	3	1.76	9.76	49.40	1.76	9.76	49.40	2.11	11.72	42.98
	4	1.43	7.95	57.36	1.43	7.95	57.36	1.94	10.79	53.77
	5	1.23	6.84	64.20	1.23	6.84	64.20	1.88	10.43	64.20
Social	1	2.76	17.27	17.27	2.76	17.27	17.27	2.57	16.03	16.03
	2	2.38	14.88	32.15	2.38	14.88	32.15	2.13	13.30	29.33
	3	1.68	10.50	42.65	1.68	10.50	42.65	1.69	10.57	39.90
	4	1.58	9.86	52.50	1.58	9.86	52.50	1.63	10.21	50.10
	5	1.19	7.42	59.93	1.19	7.42	59.93	1.57	9.82	59.93
Environmental	1	4.34	22.85	22.85	4.34	22.85	22.85	3.46	18.22	18.22
	2	3.30	17.39	40.23	3.30	17.39	40.23	2.74	14.40	32.62
	3	2.13	11.19	51.43	2.13	11.19	51.43	2.55	13.40	46.02
	4	1.70	8.92	60.35	1.70	8.92	60.35	2.24	11.78	57.80
	5	1.35	7.12	67.47	1.35	7.12	67.47	1.84	9.66	67.47

Table 7. Rotated component matrix for the economic sustainability variables.

Components Groups	Variables	1	2	3	4	5
Ethical and Relational Factors	Eco4	**0.854**				
	Eco6	**0.790**				
	Eco3	**0.668**				
	Eco9	**0.632**				
	Eco1	**0.546**				
Financial Factors	Eco17		**0.764**			
	Eco16		**0.730**			
	Eco15		**0.616**			
Project and Management Factors	Eco5			**0.774**		
	Eco7			**0.661**		
	Eco8			**0.633**		
	Eco2	0.464	−0.425	**−0.541**		
Strategic Factors	Eco10				**0.821**	
	Eco11	0.498			**0.719**	
	Eco12				**0.654**	
Key Factors	Eco13					**0.795**
	Eco14		0.438			**0.773**
	Eco18	0.394				**0.572**

Note: Rotation method: Varimax with Kaiser normalization. Bold numbers represent the highest loading values.

Table 8. Rotated component matrix for the social sustainability variables.

Components Groups	Variables	1	2	3	4	5
Historical and Social Relations Factors	Soc3	**0.827**				
	Soc2	**0.783**				
	Soc12	**0.586**	−0.356			
	Soc6	**0.501**				
	Soc4	**0.490**				
Participants Factors	Soc 9		**0.787**			
	Soc10		**0.767**			
	Soc8		**0.606**			
	Soc7	0.389	**0.481**			
Key Factors	Soc13			**0.747**		
	Soc1			**−0.674**		
	Soc4			**0.528**		−0.505
Organization and Society Factors	Soc16				**0.858**	
	Soc15				**0.759**	
Social Action Factors	Soc11					**−0.661**
	Soc5			0.374		**0.603**

Note: Rotation method: Varimax with Kaiser normalization. Bold numbers represent the highest loading values.

Table 9. Rotated component matrix for the environmental sustainability variables.

Components Groups	Variables	1	2	3	4	5
Material Usage Factors	Env9	**0.925**				
	Env8	**0.904**				
	Env10	**0.817**				
	Env12	**0.758**			0.410	
Compatibility and Protection Factors	Env15		**0.819**			
	Env17		**0.738**			
	Env14		**0.721**			
	Env18		**0.578**			
	Env1		**0.572**	−0.366		
Environmental Responsibility (Key) Factors	Env5			**0.797**		
	Env6			**0.792**		
	Env7			**0.739**		
	Env4			**0.653**		
Political and Other Factors	Env13				**0.741**	
	Env19		0.362		**0.663**	
	Env11	0.560			**0.571**	
Conscious Consumption Factors	Env2					**0.757**
	Env3					**0.707**
	Env1					**0.701**

Note: Rotation method: Varimax with Kaiser normalization. Bold numbers represent the highest loading values.

The first part of the questionnaire gathered general information regarding the respondents, such as gender, educational level, current role in the company, and years of experience in the construction industry. In addition, this section included information about the responding companies, such as annual turnover, business area, operating time, and the total number of employees.

Descriptive statistical information on economic, social, and environmental sustainability variables is shown in detail in Table 5. The table shows that the variables with the highest variance in environmental sustainability are energy consumption (Env2—mean rating: 4.8), social action funding (4.7), environmental responsibility/justice (4.6), social justice (4.6), and user or community satisfaction (4.6). In addition, it is observed that the variance of many variables in this sustainability system is 4.0 or more.

Before performing factor analysis, the suitability of the data was checked by performing Kaiser–Meyer–Olkin (KMO) and Bartlett's sphericity tests. Here, the KMO test was performed to determine to what extent other variables predict a variable. In the KMO test, values that are a measure of sampling adequacy (MSA) are examined. This value should be between 0 and 1, and as it gets closer to 1, the reliability of the test increases. MSA values greater than 0.5 are at an acceptable level. Another test, the Bartlett test, examines correlations between variables. For this value to be statistically significant, it must be less than 0.05 ($p < 0.05$) [81]. Moreover, Bartlett's measure helps to check whether the correlation matrix is an identity matrix [82]. Barlett's test generated a large chi-square value (924.389), and the significance level was found to be small ($p = 0.000$). This proves that the factor analysis is appropriate for the dataset. Furthermore, the determinant of the correlation matrix helps to test the singularity effect, and if the determinant is greater than 0.00001, then there is no singularity effect. The determinant was calculated to be 1.38×10^{-3}, which is greater than 0.00001, indicating that there is no singularity effect and thereby removing the need to eliminate any variable in the previously identified list of variables.

In this study, MSA values were found to be 0.6 for economic sustainability variables, 0.6 for social sustainability variables, and 0.7 for environmental sustainability variables. Bartlett's test was found to be 442.2 for economic sustainability variables, 220.6 for social sustainability variables, and 550.6 for environmental sustainability variables. Additionally, $p < 0.001$ was found in all systems.

Table 6 presents the factor group variances and total variances for each system separately. As a result, each system consists of four factor groups. Tables 7–9 and Appendix A show the factor analysis results of each system. The names of the factor groups were determined by the researcher's intuition and judgment. Figure 2 further provides a visualization of the factor groups. According to Table 6, ethical and relational factors pose great importance for economic sustainability goals. Moreover, environmental sustainability is mostly explained by material usage factors, such as the protection of material consumption and material recyclability. Finally, social sustainability is mostly governed by the historical and social relations factors, such as supplier–contractor relations.

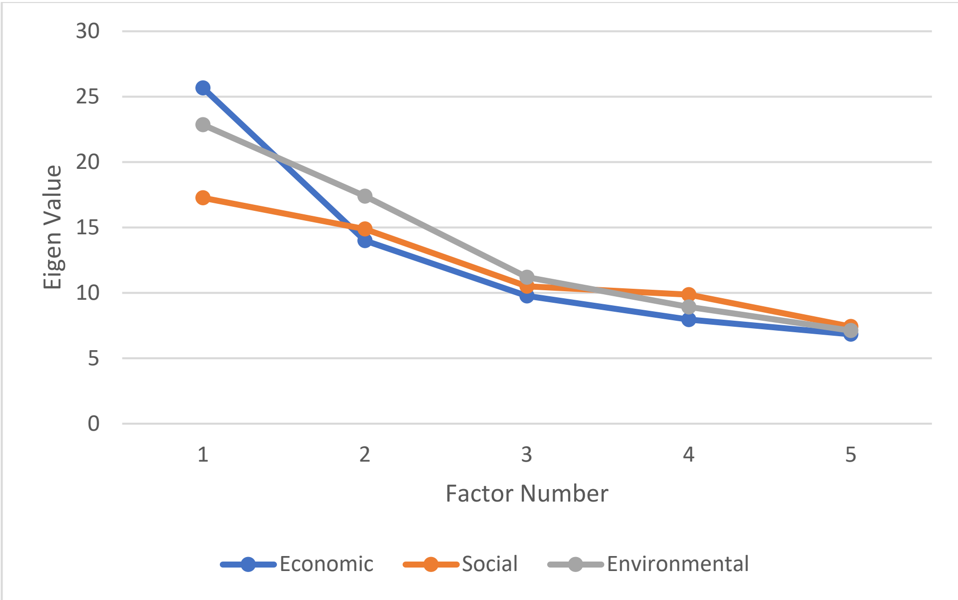

Figure 2. Total variance explained by economic, social, and environmental sustainability.

5. Discussion

5.1. Economic Sustainability

Five factor groups were identified for economic sustainability in construction projects, as can be seen in Table 7. Among these factor groups, the group with the highest variance is the ethical and relational factor group. Other groups are listed as financial, project and management, strategic, and key factors.

5.1.1. Ethical and Relational Factors

This group corresponds to 25.66% of the total variance. The highest part of economic sustainability belongs to this group. The most significant variable of this group is "Business ethics and moral obligation (Eco4)" (factor loading: 0.854; mean: 3.2). According to Akotia and Sackey [51], "Ethical and moral obligations" are an important driver of socio-economic sustainability and can serve the adoption and implementation of sustainability principles. The next most significant variable is "Supply relations, chain cooperation and integration (Eco6)" (factor loading: 0.790; mean: 3.7). In the construction industry, integrating sustainability into the supply chain can provide significant economic benefits, such as cost and time savings [83]. The variable with the third highest factor load is "Customer relationship management (Eco3)" (factor loading: 0.668; mean: 3.7), which is critical in terms of managing sustainability, especially for the economic aspects. The variable with the fourth highest factor load is "Scope control and business scope (Eco9)" (load: 0.632; mean: 3.8). For Tabish and Jha [73], the quality of the scope of work is the most critical factor against corruption, especially in the pre-project phase. The last variable in this factor group is "Innovation management/new product (Eco1)" (factor loading: 0.546; mean: 4.0). As several research studies emphasized, innovation and new product development are of utmost importance for sustainable development [64,65,75].

5.1.2. Financial Factors

This factor group explains 13.99% of the total variance and is the second group with the highest variance of economic sustainability. The most significant variable in this group is "Business success/Financial benefits of practices (Eco17)" (load: 0.764; mean: 4.1). According to Xue et al. [75], besides financial benefits, the career development of employees plays an important role in the development of the company. Similarly, Martens and Carvalho [76] mention that financial benefits lie in job creation, good health and safety performance, education, and training. "Internal rate of return and return on investment, capital budget (Eco16)" (factor loading: 0.730; mean: 4.4) and "End of building cost (Eco15)" (load: 0.616; mean: 3.9) are the second and third variables, respectively. According to Zhong and Wu [52], end-of-life building costs are not important in economic sustainability as they are not paid by current customers. However, according to Kamali and Hewage [60], end-of-life building costs contribute to economic sustainability, albeit slightly.

5.1.3. Project and Management Factors

The total variance explained by this group is 9.76%. The variable with the largest factor load is "Cost management plan (Eco5)" (loading: 0.774; mean: 4.3). Sustainability impacts in the project are determined in the early design phase, where most of the project costs are determined [62]. The next variable with the highest factor load is "Contribution to GDP (Eco7)" (load: 0.661; mean: 4.2). This variable includes contribution to gross domestic product (GDP) as well as criteria such as company value and market share performance. Labuschagne et al. [69] stated that the United Nations considers the gross domestic product or gross national product per capita when evaluating the economic performance of a country. Therefore, this criterion can also be attributed to economic performance. The third variable with the highest factor loading is "Project Control and management (Eco8)" (loading: 0.663; mean: 4.3). The last variable in this group is "Stakeholder/customer engagement and demand (Eco2)" (loading: 0.541; mean: 3.6). According to Lankoski [84], monitoring stakeholder demands is a corporate responsibility so that a company can maximize its profits. In addition, these demands play an important role in the company's adoption of sustainability.

5.1.4. Strategic Factors

The total variance of this group consisting of three variables was 7.95%. "Competitiveness and growth (Eco10)" is the most important variable of this group, with a factor loading of 0.821 and mean of 4.0. According to Okoro [85], companies that integrate sustainability principles into their business plans to increase their global competitiveness in the sector can increase the ethical responsibility and awareness of the company. The second and third variables of this group are "Organizational (Organization) culture (Eco11)" (loading: 0.719; mean: 3.6) and "Strategic planning and management (Eco12)" (loading: 0.654; mean: 3.7), respectively. Okoro [85] further implied that sustainability is part of effective planning in strategic management and should be integrated as part of organizational culture.

5.1.5. Key Factors

The total variance of this group, consisting of three variables, was 6.84%. The variable with the largest factor load is "Quality and management (Eco13)" (load: 0.795; mean: 3.5). As Sarkis et al. [62] implied, quality and management play an important part in achieving economic sustainable development. The next most significant variable is "Taxes and tax policy (Eco14)" (load: 0.773; mean: 3.6). To ensure the sustainability of construction projects, especially at the feasibility stage, a balance of interests between economic stakeholders should be maintained by the government through taxes and policies [74]. The final variable in this group is "Internalization (Eco18)" (load: 0.572; mean: 3.2). Indeed, Martens and Carvalho [76] indicate that internalization is an effective means of economic sustainability.

5.2. Social Sustainability

Five factor groups were identified for social sustainability in construction projects, and the variables of these factor groups are shown in Table 8. Among these factor groups, the group with the highest variance is relational factors. Other groups are listed as user (public)-related factors, cultural factors, and social factors, respectively.

5.2.1. Historical and Social Relations Factors

This group accounts for 17.26% of the total variance. The largest part of social sustainability belongs to this group. In this group, "Stakeholder involvement/management (Soc3)" (factor loading: 0.827; mean: 3.4) ranks first, while "Supplier–Contractor relationship (Soc2)" (factor load: 0.783; mean: 3.4) ranks second. These factors, which are the first two variables, cause significant concerns in the sector about social sustainability. As a matter of fact, according to Martens and Carvalho [76], partnerships with suppliers in the supply chain and responsibilities for products or services in stakeholder management raise significant concerns regarding sustainability. "Communication between stakeholders (Sos12)" (factor loading: 0.586; mean: 3.8) ranks third, while "Local employment (Soc6)" (factor loading: 0.501; mean: 3.7) ranks fourth. Xue et al. [75] highlighted that communication between stakeholders is critical for a social sustainability scheme. The last ranked item of this factor group was "Cultural heritage (Soc4)" with a factor loading of 0.490 and a mean of 3.3. According to Stanitsas et al. [64], by following sustainability indicators such as sustainability awareness and considering cultural heritage, project managers can improve projects and increase sustainability success.

5.2.2. Participants Factors

The total variance of this group is 14.88%. The variable with the largest factor load is the "User or community satisfaction (Soc9)" (loading: 0.787, mean: 4.3). Nair and Nayar [78] underlined that user or community satisfaction directly contributes to social sustainability to improve sustainable practices. "Public participation and compliance (Soc10)" (loading: 0.767; mean: 4.5) was rated as the second variable of this factor group. This variable was ranked 16th in the study conducted by Fernández-Sánchez and Rodríguez-López [59] in which more than 80 economic, environmental, and social sustainability variables were evaluated based on the order of importance. The next variable with the highest factor loading is "Social justice (Soc8)" (load: 0.606; mean: 4.6). According to Hill and Bowen [77], social justice is the most difficult component in sustainable construction projects (especially individual projects). Finally, "User (public) safety and health (S8)" was rated as the last ranked variable in this factor group with a loading of 0.481 and a mean of 3.8. Shen et al. [74] discussed that public safety and health are critical matters in terms of promoting social sustainability.

5.2.3. Key Factors

The total variance of this group consisting of two variables was 10.50%. "Social integration (Soc13)" (loading: 0.747; mean: 4.5) was ranked as the highest ranked item in terms of this factor group. Fernández-Sánchez and Rodríguez-López [59] listed social integration as an important variable of social sustainability in terms of promoting sustainable practices. "Labor (Worker) practices (health, safety and working conditions, education, and training) (Soc1)" was ranked as the second most important variable of social factors group with a factor loading of −0.674 and a mean of 4.0. Similarly, Chen et al. [58] determined that the variable with the highest severity in social sustainability is "workers' health and safety" in their study. “Environmental and sustainability awareness (Soc14)” was ranked as the last item of this factor group with a factor loading of 0.528 and a mean of 4.5.

5.2.4. Organization and Society Factors

The variance of the fourth factor group was 9.86. “Community/people’s needs assessment and improvement of quality of life (Soc16)” (loading: 0.858; mean: 4.0) was ranked as the highest item in terms of this factor group. Hill and Bowen [77] further implied that increasing the quality of life of people is among the social principles of sustainability, and this goal can only be achieved if poverty is reduced. “Corporate sustainability and organizational culture (Soc15)” (load: 0.759; mean: 3.9) was rated as the second variable of this factor group. Indeed, Stanitsas et al. [64] mentioned that organizational culture and sustainability at the corporate level are of utmost importance for social sustainability development.

5.2.5. Social Action Factors

The variance of the fourth factor group was 7.42. “Social action funding (philanthropy and corporate citizenship, government social projects, leadership, and social impact) (Soc11)” was ranked as the most important variable in this factor group, with a loading of 0.661 and a mean of 4.7. Finally, “Equality, justice, and ethical behavior (Soc5)” (loading: 0.603; mean: 4.6) was ranked as the last variable of this factor group. Martens and Carvalho [76] indicated that social equality, justice, and ethical behavior should be carefully taken into consideration to ensure sustainability in projects.

5.3. Environmental Sustainability

Five factor groups have been determined for environmental sustainability in construction projects and Table 9 shows these factor groups. Among these factor groups, the group with the highest variance is the key environmental factors. Other groups are listed as material-related, policy-related, regional, and energy-related factors, respectively.

5.3.1. Material-Related Factors

This group corresponds to 22.85% of the total variance. The highest part of environmental sustainability belongs to this group. The most significant variable of this group is “Material reduction, such as using recycled materials and/or reusing structural element (Env9)” (loading: 0.925; mean: 4.0). The second variable is “Material reusability (Env8)” (loading: 0.904; mean: 4.0), and the third variable is “Material consumption (Env10)” (loading: 0.817; mean: 3.9). The fourth variable in the group is “Material recyclability (Env12)” (load: 0.758; mean: 4.1). According to Enshassi et al. [66], reusability and recyclability rank first in the environmental sustainability factor ranking and moderately affect sustainability performance.

5.3.2. Compatibility and Protection Factors

This group corresponds to 17.39% of the total variance. The second largest part of environmental sustainability belongs to this group. The first variable in the group was “Environmental education and training (Env15)” (loading: 0.819; mean: 4.5). The second variable of this group is “Ecological protection and diversity (Env17)” (loading: 0.738; mean: 4.2). Ecological protection and diversity are important contributors to environmental sustainability performance. The third and fourth variable of these groups are “Adaptation to climate change (Env14)” (load: 0.721; mean: 4.5) and “Water recycling (Env18)” (loading: 0.578; mean: 4.3). The final variable of this group is “Regional (local) material use (Env16)” (loading: 0.555; mean: 4.1). Fernández-Sánchez and Rodríguez-López [59] list regional material use as an important indicator of environmental sustainability performance.

5.3.3. Environmental Responsibility Key Factors

This group corresponds to 11.19% of the total variance. The most significant variable in this group is “Soil (land) use and ecological value (Env5)” (loading: 0.797; mean: 4.1).

"Environmental responsibility/justice (Env6)" (loading: 0.792; mean: 4.6) and "Reducing environmental impacts by considering the life cycle of products and services (Env7)" (loading: 0.739; mean: 4.3) are the second and third variables, respectively. Indeed, considering the life cycle of production contributes to sustainable performance, and having a high environmental responsibility enhances the effectiveness of sustainable practices. The last variable of this group is "Available—use of suitable renewable energy sources/fossil fuels (Env4)" (loading: 0.653; mean: 4.3). In the study conducted by Fernández-Sánchez and Rodríguez-López [59], the ecological value of the soil and renewable energy use are among the 30 most important indicators.

5.3.4. Political and Other Factors

The total variance of this group, consisting of two variables, was 8.92%. Considering the factor loads, these variables were "Environmental management systems/policy implications (Env13)" (loading: 0.741; mean: 4.4). The next variable with the highest factor loading was "Emission of other harmful gases to the atmosphere (Env19)" (loading: 0.663; mean: 4.3). The last variable was "Noise pollution (Env11)" (loading: 0.571; mean: 4.2). Indeed, noise pollution (Env11) is an important indicator of environmental sustainability in terms of promoting sustainable practices.

5.3.5. Conscious Consumption Factors

The total variance of this group, consisting of two variables, was 7.12%. "Energy consumption (Env2)" (factor load: 0.757; mean: 4.8). Martens and Carvalho [76] further mention that energy consumption is a critical item when evaluating environmental sustainability performance. The next variable is "Waste generation and management (Env3)" (loading: 0.707; mean: 4.8). While buildings consume 30% of the world's energy and 40% of its resources, they also produce approximately 40% of the world's waste (2020). The variable with the last factor load is "Water quality impact and consumption (Env1)" (factor loading: 0.701; mean: 4.3). In their study, Nair and Nayar [78] emphasized the importance of water saving, recycling, and reducing water pollution, emphasizing the necessity of applying effective water-saving measures in building design. This clearly shows the importance of resource, waste, and energy management in environmental sustainability in the construction industry.

Sustainability is becoming increasingly important across all sectors, including the construction industry. Studies and reports published in recent years on sustainability in the construction sector emphasize the significance of the issue. It is crucial to address sustainability as a whole in the industry, identify the barriers to the full implementation of sustainable construction, and take the necessary regulatory and improvement steps as soon as possible.

This study has identified five distinct factors for each sustainability system. These factors have been identified as follows: for economic sustainability, ethical and relational factors, financial factors, project and management factors, strategic factors, and key factors; for social sustainability, historical and social relations factors, participants factors, key factors, organization and society factors, and social action factors; and for environmental sustainability, material usage factors, compatibility and protection factors, environmental responsibility (key) factors, political and other factors, and conscious consumption factors. In a study conducted by Chen et al. [58] on sustainability in construction project management, the economic factors are defined as "long-term cost", "constructability", "quality", and "first cost". The social factors are identified as "impact on health and community" and "architectural impact", while the environmental factor is defined as "environmental impact". Additionally, this study, conducted in 2010, considered 33 variables.

The differences in the results suggest that the number of variables, priorities, and factor groups may vary depending on the study's scope, technological advancements, and the industry's awareness. Each study contributes to the next and supports the implementation of sustainable construction by building upon previous research.

6. Conclusions

This study investigated the critical success factors for sustainability in the construction industry. To list the success factors of sustainable construction within economic, social, and environmental systems, a questionnaire was designed by conducting a comprehensive literature review for each system. In this regard, this questionnaire was applied to 101 construction companies included in Engineering News-Record's (ENR) 2019 Best Contractors List in the USA.

According to the data obtained, factor analyses were conducted for each sustainability system and five factor groups were determined for each system. The study showed that ethical and relational factors, financial factors, project and management factors, strategic factors, and key factors are strong components of economic sustainability. Furthermore, it was found that historical and social relations factors, participants factors, key factors, organization and society factors, and social action factors are factors explaining social sustainability. The results further revealed that material usage factors, compatibility and protection factors, environmental responsibility (key) factors, political and other factors and conscious consumption factors are the most important factor groups representing environmental sustainability. The closer evaluation of such factor groups indicated that ethical and relational factors have the highest variance in economic sustainability; historical and social relations factors have the highest variance in social sustainability, and material usage factors has the highest variance in environmental sustainability.

The results of this study are expected to guide researchers and policymakers in terms of revising and revisiting their sustainability practices and developing further research to provide strategies for higher sustainability performance. On the other hand, the study had limitations, such as target audience for the questionnaire selected in a single country. However, the audience was selected based on various other criteria to prevent bias.

This study has several theoretical and practical implications. This study could further help researchers in terms of developing multi-criteria decision-making models of sustainability implementation with respect to the three pillars of sustainability. Moreover, researchers should produce sustainability implementation guides, where critical areas in construction are identified. In terms of practical implications, the results of this study can help construction companies establish new sustainability programs encompassing the success factors highlighted in this study. Moreover, construction companies can benefit from the findings of this study by developing sustainability teams based on a critical assessment of knowledge, competency, and expertise in sustainability implementation.

In future research studies, causal models shall be developed to better explain relations among various factors of sustainability and to measure sustainability performance in the construction industry. There is a need for more research on topics such as the challenges faced during the implementation of sustainable construction and success criteria. Furthermore, the extent to which environmental, economic, and social sustainability factors are applied in the construction sector, as well as the stages and levels of companies' adoption and implementation of these three core systems, are also important areas that require investigation. Even though this study had some limitations, such as relatively smaller sample size and data collected from a single country, considering the years of experience of the respondents in both sustainable construction and the industry, the results of the study could be generalized as it provides a comprehensive list of success factors for achieving a sustainable organization.

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Appendix A

Economic Sustainability		
Components Groups	**Variables**	
Ethical and Relational Factors	Eco4	Business ethics and moral obligation
	Eco6	Supply relations, chain cooperation and integration
	Eco3	Customer relationship management
	Eco9	Scope control and business scope
	Eco1	Innovation management/new product development/productivity and flexibility
Financial Factors	Eco17	Business success/Financial benefits of practices
	Eco16	Internal rate of return and return on investment, capital budget
	Eco15	End of building cost
Project and management Factors	Eco5	Cost management plan (costs, returns on investment. . .)
	Eco7	Contribution to gross domestic product (GDP) (economic performance—income and employment)
	Eco8	Project Control and management
	Eco2	Stakeholder/customer engagement and demand
Strategic Factors	Eco10	Competitiveness and growth
	Eco11	Organizational (Organization) culture
	Eco12	Strategic planning and management
Key Factors	Eco13	Quality and management
	Eco14	Taxes and tax policy
	Eco18	Internationalization
Social Sustainability		
Components Groups	**Variables**	
Historical and social relations Factors	Soc3	Stakeholder involvement/management
	Soc2	Supplier–contractor relationship
	Soc12	Communication between stakeholders
	Soc6	Local employment (capacity)
	Soc4	Cultural heritage
Participants Factors	Soc 9	User or community satisfaction
	Soc10	Public participation and compliance
	Soc8	Social justice
	Soc7	User (public) safety and health

Social Sustainability		
Components Groups	**Variables**	
Key Factors	Soc13	Social integration
	Soc1	Labor (Worker) practices (health, safety, and working conditions, education, and training)
	Soc14	Environmental and sustainability awareness
Organization and Society Factors	Soc16	Community/people's needs assessment and improvement of quality of life
	Soc15	Corporate sustainability and organizational culture
Social action Factors	Soc11	Social action funding (philanthropy and corporate citizenship, government social projects, leadership and social impact)
	Soc5	Equality, justice and ethical behavior
Environmental Sustainability		
Components Groups	**Variables**	
Material Usage	Env9	Material reduction, such as using recycled materials and/or reusing structural element
	Env8	Material reusability (potential that structural materials can be reused for the next project)
	Env10	Material consumption
	Env12	Material recyclability (potential that structural materials can be recycled for future use)
Compatibility and Protection	Env15	Environmental education and training
	Env17	Ecological protection and diversity
	Env14	Adaptation to climate change
	Env18	Water recycling
	Env1	Regional (local) material use
Environmental Responsibility (Key)	Env5	Soil (land) use and ecological value
	Env6	Environmental responsibility/justice
	Env7	Reducing environmental impacts by considering the life cycle of products and services
	Env4	Available—use of suitable renewable energy sources/fossil fuels
Political and Other	Env13	Environmental management systems/policy implications
	Env19	Emission of other harmful gases to the atmosphere
	Env11	Noise pollution
Conscious Consumption	Env2	Energy consumption
	Env3	Waste generation and management
	Env1	Water quality impact and consumption

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