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Sustainable construction strategies for building construction projects in the Kingdom of Bahrain: a model

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Abstract

Sustainability is defined as meeting the demands of the present without compromising the ability of future generations to meet their own needs. This study focuses on the sustainable construction strategies used in the Kingdom of Bahrain in terms of sustainable construction technologies and management strategy linked to the environment and the significant relationship between the management strategy and construction technologies used for sustainable building construction. This study employed the descriptive-correlational method of research using a questionnaire for gathering data about the sustainable construction strategies used in Bahrain. The data gathered were analyzed using the weighted mean and Pearson's correlation coefficient to determine the degree of correlation between construction technologies and management strategy. SPSS software was used in the calculation.

Results show that management strategy linked to the environment is often practiced in around 75% of all projects delivered while general sustainable construction methods, energy and material-based techniques, and waste-based techniques are sometimes utilized in around 50% of all the building projects delivered. In addition, the utilization of these sustainable construction technologies is the result of a management strategy linked to the environment which the respondents rated as often practiced for all projects that were delivered. This implies that management strategy in protecting the environment in Bahrain is often practiced in construction for 75% of the projects.

From the results of the study, a model of sustainable building construction in the Kingdom of Bahrain was derived to achieve sustainable building construction. This includes the management strategies needed by the different stakeholders like construction firms and government agencies to carry out the implementation of sustainable construction and sustainable construction techniques (e.g., waste management, insulating materials, building envelope with thermal properties, building management system, and efficient fixtures).

Keywords: Sustainable construction, Construction technology, Building construction, Efficient materials

1. Introduction

Sustainability is described as "filling the requirements of the present without compromising the ability of future generations to fulfill their own needs" by the United Nations Brundtland Commission [1]. This has

been a challenge for all disciplines and industries; to rethink their corresponding methods utilized due to the alarming climate change experience around the world.

Sustainable construction uses recyclable and renewable materials in construction projects to reduce energy use and harmful waste. By its very nature, the construction sector is one of the most significant consumers of minerals and natural resources [2]. Some books and articles would say that the construction industry is one of the industries which contributes to a big percentage of waste generation. In fact, sustainable construction is already one subject that has been integrated into the school curriculum in European countries for the purpose of increasing the level of awareness towards sustainability methods.

The construction industry's widespread adoption of the linear economic model stipulates that materials are used to construct buildings and are then disposed of once they have served their purpose. Due to this both the exploitation of natural resources and the generation of 25% of the world's solid waste are its responsibility [3]. Environmental concerns at the construction stage are frequently disregarded or approximated, despite the short-term and severe environmental effects of the usage level [4]. The life cycle for creating industrialized structures is short, there isn't much agreement on methodologies or techniques, and it is unknown how building industrial structures will affect the environment [5]. This traditional method, which some parts of the world are still using, continuously generates construction waste. A study conducted by Ametepey et.al, stresses a strong emphasis on economic development at the expense of the environment that these activities have an impact on. The results of this study show that a concerted effort from the many actors within the construction sector will be needed if environmental considerations are to be effectively incorporated into construction activities in Ghana [6].

In Bahrain, construction activities are being observed. With this, it is expected that large amounts of waste will be generated as well as carbon emissions in the construction activities. According to my study on the construction updates in Bahrain, the construction industry is Bahrain's fastest-growing non-oil industry, which significantly contributes to the nation's development [7]. The construction activities in Bahrain will continue to contribute to the generation of waste and to the harmful effects on the environment if sustainable construction methods are not utilized.

Due to the extensive effects of climate change on this planet, sustainable development has been at the forefront of discussions. This is primarily a result of the operations of industries that harm the environment and deplete non-renewable resources to support our development and expansion [8]. Climate change is already a global concern for all industries. In construction industries, achieving sustainable methods is a very big question in all the stages of the project’s lifecycle. From a civil engineer’s observations, there are still some construction companies in Bahrain that use traditional methods of construction from pre- to post-construction stages. Failing to adapt and utilize the use of sustainable construction strategies may be due to a lack of educational awareness, financial and technical incapacities, an unwillingness to try new methods, and regulation issues. Mavi et al. discovered that the idea of sustainability ought to be incorporated into building projects from the very beginning of design and feasibility studies and that it ought to be followed up all the way through the projects. Further, high costs have a negative influence on the environment, but data suggest that the construction sector can concurrently improve its economic and environmental performance [10].

Aiming to enforce the application of sustainable solutions and green buildings in design, construction, operations as well as maintenance, the Ministry of Works (MoW) has set up strategic plans in order to fulfill its mission to create a green building and sustainability program in accordance with Bahrain Vision 2030 [11]. According to the study of Minhas and Potdar (2020) on the “Development of an Effective System for Selecting Construction Materials for Sustainable Residential Housing in Western Australia”, construction has undergone a revolution thanks to urbanization and improved living conditions. To increase the overall effectiveness of construction and decrease waste both during and after the activity, a variety of techniques and strategies have been tried; some are more cost-effective than others [12]. In addition, the industry has evolved its processes in project delivery to achieve environmentally friendly methods of construction. This includes some automated construction procedures. For instance, construction technology that uses 3D printing produces less

environmental pollution and reduces waste on construction sites [13]. Achieving sustainable methods of construction remain an issue in the industry as noted by Ayarkw et.al. The authors specifically mentioned the difficulties in getting project management teams to adopt sustainable building practices [14]. In addition, the study of Darko, et.al emphasizes the necessity to increase government involvement in the deployment of green building technology [15]. It is for this very reason that this study is conducted: to increase the level of awareness of everyone in the construction industry, as well as to help them cope with the rapid increase of technologies used in achieving sustainable construction strategies in the Kingdom of Bahrain.

1.1 Research problem

This study aimed to find out the sustainable construction strategies used for building construction projects in the Kingdom of Bahrain. Specifically, it tried to answer the following questions:

a. What are the sustainable construction strategies used in the Kingdom of Bahrain in terms of construction technology and management strategy linked to the environment?

b. Is there a significant relationship between the management strategy and construction technology used for sustainable building construction strategies?

c. What Sustainable Building Construction Strategies Model could be formulated for the Kingdom of Bahrain?

1.2 Conceptual framework

This research is based on the idea that the challenges and solutions regarding the implementation of sustainable construction strategies are identified through acknowledgment of the construction industry and the current practices on sustainability. In this way, we will be able to assess the level of industry knowledge on sustainable methods in construction and then compare these practices to international standards.

The participants of this study will be engineers and architects who are actively involved in construction projects. They will be asked about the sustainable construction strategies used in the Kingdom of Bahrain in terms of technology, energy-based, material-based, and waste-based techniques, as well as management strategies concerning the environment.

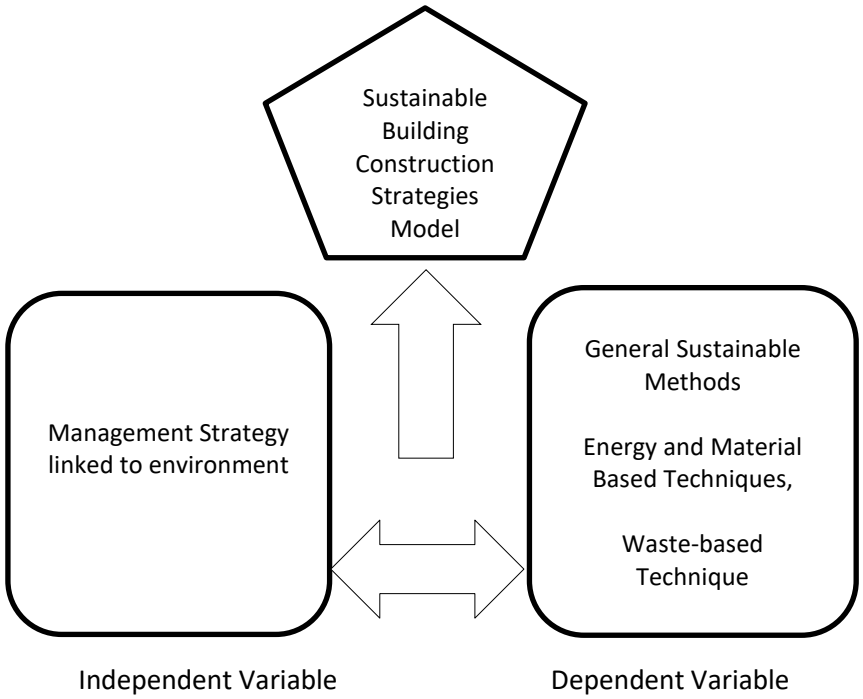

Figure 1. The schematic diagram of the relationship between the independent and dependent variables

2. Methodology

2.1. The Respondents

The participants of this study who identified the sustainable construction strategies used for construction projects in the Kingdom of Bahrain in terms of construction technology and management strategy were the 92 engineers working in private companies and ministries in this country.

The participants completed the questionnaire by giving their ratings regarding the sustainable construction strategies used in projects across the Kingdom of Bahrain. The ratings considered construction technologies and management strategies regarding the environment.

2.2. Research design

This study employed the descriptive-correlational method of research. It focused on identifying sustainable construction strategies used in the Kingdom of Bahrain in terms of construction technology and management strategy linked to the environment. Correlational studies are designed to help determine the relationship and degree to which different variables are related to each other. Quantitative research is the process of gathering and interpreting numerical data. It can be used to identify trends and averages, formulate hypotheses, examine causality, and extrapolate findings to larger populations. With a correlational research design, relationships between variables are examined without any of the variables being under the researcher's direct control or manipulation [16].

2.3. Scoring and interpretation

Construction technology. This includes general sustainable construction methods, energy, and material-based and waste-based techniques.

5 – Extremely utilized,	100% across all projects
4 – Often utilized,	75% across all projects
3 – Sometimes utilized,	50% across all projects
2 – Rarely utilized,	25% across all projects
1 – Never utilized,	0% across all projects

The result was interpreted using the scale with the corresponding interpretation as stated below:

Range	Description
4.501 - 5.000	Extremely utilized
3.501 - 4.500	Often utilized
2.501 - 3.500	Sometimes utilized
1.501 - 2.500	Rarely utilized
1.000 - 1.500	Never utilized

Management strategy. This includes management strategy in relation to environmental sustainability.

5 – Extremely practiced,	100% across all projects
4 – Often practiced,	75% across all projects
3 – Sometimes practiced,	50% across all projects
2 – Rarely practiced,	25% across all projects
1 – Never practiced,	0% across all projects

The result was interpreted using the scale with the corresponding interpretation as stated below:

Range	Description
4.501 - 5.000	Extremely practiced
3.501 - 4.500	Often practiced
2.501 - 3.500	Sometimes practiced
1.501 - 2.500	Rarely practiced
1.000 - 1.500	Never practiced

2.4. Validation of research instrument

The research instrument was validated by following a procedure, starting with establishing face validity. This two-step process had the questionnaire reviewed by three different experts in the field of civil engineering. The questionnaire was reviewed in terms of relevance and clarity. The next step is carried out by revising the questions based on the feedback and suggestions from the reviewers. After the questions had been reviewed, pilot testing was undertaken using Google Forms. The data collected from the administered pilot testing were checked for internal consistency using Cronbach's alpha reliability check with Cronbach's alpha value of 0.956 considered excellent for internal consistency check.

2.5. Data gathering procedures

The data was collected using a questionnaire regarding construction technology and management strategy. It was distributed to the respondents using Google Forms.

2.6. Statistical treatment of data

The data gathered were analyzed using the following statistical tools [17]: weighted mean for the data for general sustainable construction methods, energy and material-based techniques, waste-based techniques, and management strategy. The formula is:

$$X_m = \frac{NR\ X\ CP}{N}$$

Where:

X_m = Arithmetic Mean

NR = Number of responses registered in any category

CP = Number of responses assigned to any category

N= Number of Scores or cases

Pearson's Correlation Coefficient (to determine the degree of correlation between construction technologies and management strategy). SPSS will be used in the calculation.

$$R = \frac{n\sum xy-(\sum x)(\sum y)}{\sqrt{[n\sum x^2-(\sum x)^2][n\sum y^2-(\sum y)^2]}}$$

Where:

R = Pearson's Correlation Coefficient.

X = profile of the civil engineers.

Y = perceived market demands; and

n = population size.

3. Results and discussion

3.1. Sustainable construction technologies

Table 1 below shows the general sustainable construction methods as rated by the respondents. The respondents gave a rating of 3.32, which is described as sometimes used for all projects that were delivered. This implies that construction projects in Bahrain utilized sustainable methods for only 50% of the projects. The use of an effective ventilation system is the highest and most often utilized method for all projects, in approximately 75% of the delivered projects. Other often utilized methods are lighting systems, double insulated & tinted glazing, roller blinds, building management systems, UV reflected paint, dual flush low-capacity flushing cisterns, and design controls to balance available daylight. On the other hand, benches, and tables made from construction wastes are rarely used in construction. This is similar to a study done by Willar et al. where it was found that

Indonesian contractors find it difficult to apply environmental norms when carrying out construction [18]. This notion is also mentioned in a study by Yunus and Yang, employing efficient building material energy, and stabilizing work circumstances are ways to promote sustainable deliverables [19].

Table 1. General sustainable construction methods

Methods	Weighted Mean	Description
1. Greywater Plumbing Systems which reduce the facility's need for fresh water and use this for supplying toilets	2.74	Sometimes utilized
2. Modular construction methods	3.13	Sometimes utilized
3. Sun orientation of building design which helps reduce energy consumption	3.29	Sometimes utilized
4. UV-reflected paint which reduces thermal conductivity	3.66	Often utilized
5. Recycling stations for wastes	3.23	Sometimes utilized
6. Plants as a biofilter for the treatment of water	2.79	Sometimes utilized
7. Dates Palm trees that provide shade to other bearing fruits like avocado, pomegranate, etc.	2.53	Sometimes utilized
8. Bench and tables are made from construction wastes	2.46	Rarely utilized
9. Renewable materials used in retrofitting	2.58	Sometimes utilized
10. Adaptive reuse projects that transform old buildings	2.77	Sometimes utilized
11. Double Insulated & Tinted Glazing	4.00	Often utilized
12. Roller blinds, help to reduce heat gain	3.90	Often utilized
13. Use of a building management system (BMS) to monitor, control and optimize system performance	3.52	Often utilized
14. Effective ventilation system - give special attention to ventilation requirements and system configuration and controls	4.15	Often utilized
15. Lighting systems in regular maintenance procedures to ensure optimum light output and energy efficiency	4.12	Often utilized
16. Design controls to balance available daylight with the secondary need for electric light	3.72	Often utilized
17. Dual flush low-capacity flushing cisterns	3.82	Often utilized
Mean	3.32	Sometimes utilized

Note: 1.00–1.50, Never Utilized; 1.501–2.500, Rarely Utilized; 2.501–3.5, Sometimes Utilized; 3.5.1–4.50, Often Utilized; 4.501-5.000, Extremely Utilized

3.2. Energy and material-based techniques

Table 2 shows the energy and material-based sustainable methods used in Bahrain construction. The respondents' rating is 3.47 which can be interpreted as "sometimes utilized" across all delivered projects. This implies that construction projects in Bahrain utilized energy and material-based sustainable methods in only 50% of cases. The use of insulated roofs is often utilized, in approximately 75% of all delivered projects. Other often utilized methods are insulated concrete blocks, high-efficiency fixtures, led lamps, inverter-type AC and appliances, windows with thermal reflective properties, highly efficient equipment, insulated ducts, programmable thermostat, and zone control of heating. On the other hand, recycled paper products used to form cellulose loose-fill insulation are rarely used in construction. Though these methods are sometimes utilized in construction projects across the Kingdom of Bahrain, they have been recognized in the field, and according to Abramyan et al., the market for construction technologies will see more advanced materials and technologies ensuring the energy efficiency of facade systems in buildings [20]. In Europe, material research helps achieve

future energy and climate goals, since it takes into account the significance of raw materials for the energy industry and the future of advanced materials for low carbon emissions, as energy is a pertinent issue in Europe [21].

Table 2. Energy and material-based techniques

	Methods	Weighted Mean	Description
1.	Solar panels built into roof tiles format	3.07	Sometimes utilized
2.	Recycled paper products used to form cellulose loose-fill insulation	2.41	Rarely utilized
3.	Synthetic roof underlayment which uses a polymer that comes from recycled scrap materials	2.55	Sometimes utilized
4.	High-efficiency fixtures, lamps, and controls such as led lamps, inverter-type AC, and appliances	3.80	Often utilized
5.	Windows with thermal reflective properties	3.92	Often utilized
6.	Insulated concrete blocks	4.24	Often utilized
7.	Insulated roofs	4.33	Often utilized
8.	Human Sensor type of electrical and mechanical fixtures	3.21	Sometimes utilized
9.	Water fittings with water efficiency labels	3.59	Often utilized
10.	Mechanically highly efficient equipment such as highly efficient energy ratio (EER), reputable manufacturer, certified equipment, safe accessories, coated coils, etc.	3.74	Often utilized
11.	A programmable thermostat that is designed to adjust the temperature according to a series of programmed settings that take effect at various times of the day	3.57	Often utilized
12.	Pre-insulated ducting in the HVAC industry is installed in a single fix, eliminating the need for a second fix which saves significant time and cost	3.85	Often utilized
13.	Zoning and zone control of heating, ventilating, and air conditioning (HVAC) systems. A well-designed zoning system can save in energy costs each year	3.71	Often utilized
14.	A BMS is a computer-based control system installed in buildings that control and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems.	3.47	Sometimes utilized
15.	Insulated water tanks	3.86	Often utilized
16.	Delay taps & sensor taps, use of water fittings with water efficiency labels	3.28	Sometimes utilized
17.	Programmable astronomic or solar digital timer, all external lights are automatically controlled and calculate the sunrise & sunset times for each day of the year	2.95	Sometimes utilized
18.	Lighting control system, master control (touch screen) of lighting in the control room	3.23	Sometimes utilized
19.	Stand-alone external pole lights are solar operated	3.16	Sometimes utilized
Mean		3.47	Sometimes utilized

Note: 1.00–1.50, Never Utilized; 1.501–2.500, Rarely Utilized; 2.501–3.5, Sometimes Utilized; 3.5.1–4.50, Often Utilized; 4.501-5.000, Extremely Utilized

3.3. Waste-based techniques

Table 3 shows the waste-based sustainable methods used in construction in the Kingdom of Bahrain. The respondents' rating is 2.99 interpreted as sometimes utilized across all delivered projects. The use of waste management is often utilized for approximately 75% of all the delivered projects. Another often utilized method is packaging carefully to prevent breakages. On the other hand, melted and reformed glass has the lowest rate which is rarely used in construction. This implies that construction projects in the Kingdom of Bahrain utilized waste–based sustainable methods in only 50% of projects. This is parallel to the study by Kumawat et al., where it was argued that the safe management and disposal of waste building materials has been the subject of extensive investigation in the construction industry [22]. Oliveira et al. also cited that the sampled construction businesses do not recycle or utilize construction debris, instead, they dump it in public or unofficial landfills [23].

Table 3. Waste-based techniques

	Methods	Weighted Mean	Description
1.	Recycling materials back into the process e.g., steelwork	3.22	Sometimes utilized
2.	Controlling waste management, such as separating and recycling waste	3.71	Often utilized
3.	Using the waste as fuel for energy production	2.43	Rarely utilized
4.	Packaging carefully to prevent breakages	3.52	Often utilized
5.	Training on the use of material	3.50	Sometimes utilized
6.	Education on waste which costs the environment	3.33	Sometimes utilized
7.	Crushed concrete used as fill material to raise levels	3.11	Sometimes utilized
8.	Facing bricks cleaned and re-used to give a house an aged appearance	2.72	Sometimes utilized
9.	Redressed or crushed slates combined with an adhesive to form a reconstituted slate tile	2.46	Rarely utilized
10.	Melted and reformed glass	2.17	Rarely utilized
11.	Recycled steel used in the production of structural steel	2.77	Sometimes utilized
	Mean	2.99	Sometimes utilized

Note: 1.00–1.50, Never Utilized; 1.501–2.500, Rarely Utilized; 2.501–3.5, Sometimes Utilized; 3.5.1–4.50, Often Utilized; 4.501-5.000, Extremely Utilized

3.4. Management strategy linked to the environment

Table 4 shows the management strategy linked to the environment as rated by the respondents. The respondents gave a rating of 3.75, which is often practiced for all projects that were delivered. This implies that management strategy in protecting the environment in Bahrain is often practiced, specifically in 75% of the projects. The practice of stakeholders performing key roles to collectively achieve sustainability in construction and designers showing environmental consciousness in their design is the highest and most frequent practice across approximately 75% of the delivered projects. On the other hand, the recycling of other construction materials from waste generated by construction activities is sometimes practiced in all construction projects.

This further showed how construction management initiates protecting the environment through sustainable construction methods. According to the study by Dawodu et al., while there is no doubt that the built environment has improved in terms of sustainability, there are undiscovered gaps in the NSAT (Neighborhood Sustainability Assessment Tools) frameworks that may limit their future use for sustainable urban planning and design [24]. This means that management for sustainable construction must look closely at frameworks like BREEAM or LEED regarding the certification of sustainable buildings. In addition, Shan et al. cited that practices of sustainable building projects are favorable since they provide practitioners with a thorough

understanding of sustainable methods and financing as well as enhancing their experience and knowledge in this field [25].

Table 4. Management Strategy linked to the environment

Methods	Weighted Mean	Description
1. Clients consider environmental track records when selecting consultants and contractors	3.63	Often practiced
2. Consultants/designers consider environmentally friendly materials in their design	3.74	Often practiced
3. Waste generated from construction activities is recycled into other construction materials	3.15	Sometimes practiced
4. Contractors help in the campaign by ensuring all government-funded construction projects are environmentally friendly	3.57	Often practiced
5. Education and awareness campaign in promoting environmentally sustainable construction.	3.54	Often practiced
6. Clients consider environmental protection as a project objective in all projects in addition to the traditional objectives i.e., cost, time, quality etc.	3.71	Often practiced
7. Contractors/builders minimize waste during construction works	3.76	Often practiced
8. Contractors support legislations, codes or standards relating to environmentally sustainable construction practices	3.92	Often practiced
9. Manufacturers create new designs which facilitate material recycling	3.41	Sometimes practiced
10. Stakeholders in the construction industry cooperate for an environmentally sustainable construction industry	3.87	Often practiced
11. Clients set up environmental policy for every project	3.84	Often practiced
12. Builders/contractors use environmentally friendly construction methods on site	3.87	Often practiced
13. Suppliers ensure materials supplied are produced through environmentally friendly means	3.78	Often practiced
14. Stakeholders such as clients, contractors, consultants, government, suppliers/manufacturers perform key role to play collectively to achieve sustainable construction	3.97	Often practiced
15. Stakeholders ensure that the final product of construction is energy efficient and environmentally friendly in its operation	3.92	Often practiced
16. Designers show environmental consciousness in their design	3.97	Often practiced
17. Environmental impact assessment is integrated into the building permit process	3.90	Often practiced
18. Stakeholders are engaged in the review of the national building regulations including some environmental regulations	3.77	Often practiced
19. Stakeholders such as contractors, are aware of the environmental protection act to be carried out for all construction projects	3.93	Often practiced

Methods	Weighted Mean	Description
20. Collaborative in educating building owners, operators, and occupants on the function and operations of installed technologies	3.86	Often practiced
21. Carry out energy audits, in collaboration with EWA (Electric and Water Authority) for selected existing buildings	3.71	Often practiced
22. Implement recommendations and monitor energy performance	3.78	Often practiced
23. Undertake LEED certification of buildings completed	3.61	Often practiced
Mean	3.75	Often practiced

Note: 1.00–1.50, Never practiced; 1.501–2.500, Rarely practiced; 2.501–3.5, Sometimes practiced; 3.501–4.500, Often practiced; 4.501-5.000, Extremely practiced

Figure 2 shows the summary of sustainable construction strategies utilized for building construction in the Kingdom of Bahrain. Specifically, management strategy is often practiced in around 75% of all delivered projects while general sustainable construction methods, energy, and material-based techniques, as well as waste–based techniques, are sometimes utilized in around 50% of all the delivered projects. This shows that management strategy has affected the utilization of sustainable construction technologies. According to a study by Kinnunen et.al, greater marketing efforts and actions lead to better sustainability performance, and greater eco-innovation capacity also leads to better sustainability performance [26].

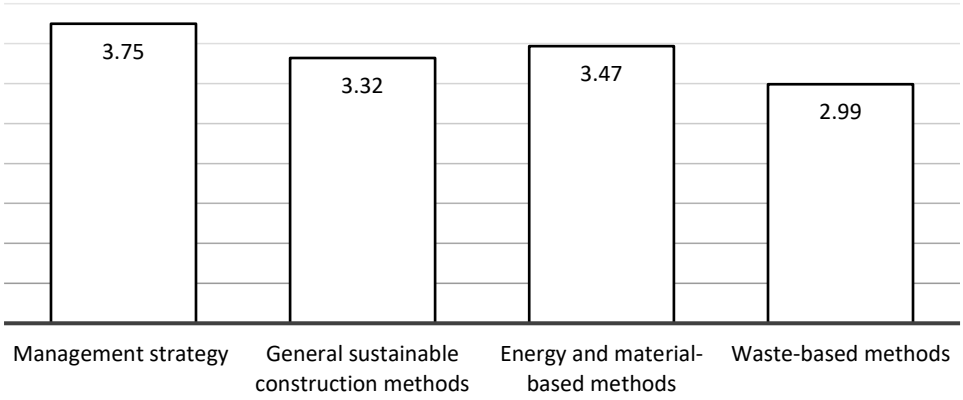

Figure 2. Sustainable building construction strategies in the Kingdom of Bahrain

3.5. Relationship between the management strategy and sustainable construction technologies

Table 5 shows the p values between sustainable construction technologies and management strategies linked to the environment. Specifically, management strategies linked to the environment and sustainable construction technologies all have p-values less than 0.001. This shows that management strategies towards the environment have significant relationships to the different sustainable construction technologies. This implies that the practice of stakeholders working collectively to achieving sustainable construction and environmentally conscious design significantly transforms into the utilization of general sustainable construction methods, energy and material, and waste – based techniques for around 50% of all the projects in the Kingdom of Bahrain.

This is similar to the findings of Solovida and Latan (2017) where it was shown that there is a direct and positive impact of environmental strategy on business performance in terms of the environment [27]. This is opposite to the study of Iqbal et al (2022), that despite the successful integration of energy management practices in developed countries, reducing energy usage and promoting energy management practices remain pressing issues

in the construction sector of developing countries where construction companies are not interested in adopting energy conservation and management practices in their projects [28].

Table 5. Pearson's correlation coefficient performed between sustainable construction technologies and management strategy to the environment

	General Sustainable Construction Methods	Energy and Material – Based Techniques	Waste – Based Techniques
Management Strategy linked to the environment	P<0.001	P<0.001	P<0.001

3.6. Model of sustainable building construction in the Kingdom of Bahrain

Figure 3 shows the model for achieving sustainable building construction in the Kingdom of Bahrain. To achieve sustainable building construction, there are two strategies that must be observed. These two strategies are as follows:

1. *Management Strategies*. These are the management strategies needed by different stakeholders like construction firms and government agencies to carry out the implementation of sustainable construction strategies.
   - 1.1 Education campaigns. This provides awareness of the benefits of sustainable construction methods in protecting the environment.
   - 1.2 Government legislations and regulations. These correspond to the environmental policies, and building regulations for compliance of construction firms, owners, and different stakeholders.
   - 1.3 Cooperation. It is the responsibility of stakeholders to cooperate for an environmentally sustainable construction industry.
   - 1.4 Key roles. Different stakeholders must perform their key roles to achieve sustainable construction.
   - 1.5 Environmental Impact Assessment (EIA). This entails evaluating any potential environmental implications of the proposed development.
   - 1.6 Energy Audit. Carry out energy audits, in collaboration with the Electrical and Water authorities to implement recommendations and monitor energy performance.
   - 1.7 LEED certification. This is a certification of compliance that evaluates the building's performance in terms of the environment.
2. *Sustainable construction technologies*. These are the sustainable construction techniques which may include energy and material-based, waste–based techniques, and construction methods.
   - 2.1 Waste Management. This refers to controlling waste management such as separating and recycling waste, packaging carefully to prevent breakages, recycling materials back into the process, crushed concrete and other materials used as fill material, and training on the use of material.
   - 2.2 Insulated Materials. This includes insulated concrete blocks and roofs, pre-insulated ducting in HVAC, insulated water tanks, and double-insulated and tinted glazing.
   - 2.3 UV-reflected
   - 2.4 Building Management Systems. This refers to the use of a building management system, effective ventilation system, lighting systems in regular maintenance, design controls to balance daylight with electric light, a programmable thermostat, and zone-controlled heating.
   - 2.5 Efficient fixtures. This refers to dual flush low-capacity flushing cisterns, high-efficiency fixtures, lamps and controls, inverter-type AC and appliances, water fittings with water efficiency labels, and mechanically highly efficient equipment.

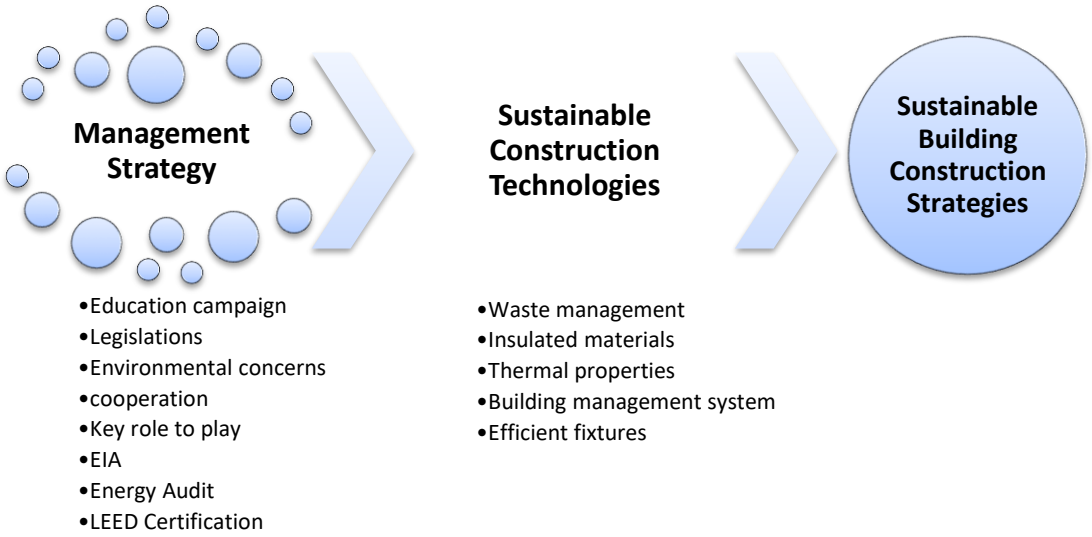

Figure 3. A model of sustainable building construction strategies in the Kingdom of Bahrain

4. Conclusions and recommendations

4.1. Conclusions

This study focused on the sustainable construction strategies used in the Kingdom of Bahrain in terms of sustainable construction technologies and management strategies linked to the environment and the significant relationship between management strategies and construction technologies used for sustainable constructions. Results showed that management strategies linked to the environment are often practiced in around 75% of all delivered projects while general sustainable construction methods, energy and material-based techniques, and waste-based techniques are sometimes utilized in around 50% of all the delivered building projects. According to Oke's study, there is a low level of adoption of sustainable construction techniques among construction professionals, despite the average level of awareness of these methods [29].

Specifically, the general sustainable construction methods are rated as sometimes used for all projects that were delivered and implied that construction projects in the Kingdom of Bahrain utilized sustainable methods for only 50% or sometimes across the projects. In terms of energy and material-based techniques, it is rated as sometimes utilized across all projects delivered which means that construction projects in Bahrain utilized energy and material–based sustainable methods in only 50% or sometimes across projects. Similarly, waste-based techniques were rated as sometimes utilized across all the delivered projects which implies that construction projects in the Kingdom of Bahrain utilized waste-based sustainable methods in only 50% or sometimes across the projects. In addition, the utilization of these sustainable construction technologies is the result of management strategies linked to the environment which the participants rated as often practiced for all delivered projects. This implies that the management strategy for protecting the environment in the Kingdom of Bahrain is often practiced in construction, specifically in about 75% of projects.

This is justified by the relationship between the management strategy and sustainable construction technologies by which the statistical tool says that the p-values are less than 0.001 between the two variables. This means that the management strategy toward the environment has a significant relationship with the different sustainable construction technologies. This is comparable to the study by Kamal et al. (2021) on the mediating role of building materials and sustainable use between the construction supply chain integration and the performance of the construction industry, which revealed that the elements of the supply chain integration had a statistically significant impact on performance [30]. The result further showed that the utilization of sustainable strategies is only in 50% of the projects which therefore the study on why the remaining 50% of projects were not able to utilize sustainable construction methods.

From these results, a model of sustainable building construction in the Kingdom of Bahrain was derived. In order to achieve sustainable building construction, there are two strategies that must be observed. First are the management strategies used by the different stakeholders (these include construction firms and government agencies). These management strategies request stakeholders to carry out the implementation of sustainable construction strategies which include education campaigns, government legislations, and regulations, stakeholders' cooperation, executed key roles, environmental impact assessment, energy audit, and LEED certifications. The second strategy is the inclusion of sustainable construction techniques which may include waste management, insulated materials, building envelope with thermal properties, building management system, and efficient fixtures.

4.2. Recommendations

After a thorough analysis of the findings of this study, the following recommendations are being proposed:

- It is recommended to practice management strategies as it is significant for the utilization of sustainable building construction strategies.
- It was found that sustainable construction strategies were utilized in only 50% of all delivered projects which poses the of question why these strategies were not utilized in more instances. It is also suggested to identify the profile of respondents who have utilized sustainable construction strategies in terms of the category of projects and background of the company.
- It is also further recommended to study the challenges faced in the utilization of sustainable strategies and the solutions utilized in addressing the challenges. Similarly, management strategies were practiced in only 75% of all delivered projects, thus, it is recommended to do research on the reasons behind this.
- Finally, it is also recommended to cluster the respondents as to their employment affiliation whether in private or public sectors to determine significant differences in terms of environmental management strategies.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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