

Towards Sustainable Construction in Iraq: Identifying Strategies and Implementation Barriers Based on Expert Opinions

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ABSTRACT

Sustainable construction in Iraq has been a major challenge, even though the construction sector plays a pivotal role in enhancing its development and the impacts that come along. The issue is that there are no clear guidelines, and there are barriers to actualizing the sustainability practices. Research was aimed at discovering and ranking sustainable construction strategies in the Iraqi environment, identifying challenges to implementation. It utilized a two- round Delphi research design with 16 professionals in the first round and 14 in the second round. In accordance with a literature review, 42 strategies and 24 barriers were first determined, then expanded to 46 strategies and 36 barriers following the recommendations of experts. The significance and degree of agreement were evaluated using statistical methods including weighted averages, coefficients of variation, Kendall coefficient, chi-square test, and stability analysis. Results led to the adoption of 36 strategies and 32 barriers after excluding factors that did not meet the established acceptance criteria. The stability rates for all the dimensions remained below the predefined threshold (15%), demonstrating the sufficiency of the two rounds of D stability rate strategies included energy-efficient building systems, occupational health and safety planning, and the consideration of sustainability requirements in contracts and project management. On the other hand, the greatest barriers were the poor legislative and regulatory frameworks, inaccessibility to sustainable technologies and materials, and financial and institutional constraints. The paper offers a guideline for policymakers, civil engineers, and project managers to rank these priorities to encourage the adoption of sustainable construction in Iraq.

Keywords: Delphi method, Expert consensus, Implementation barriers, Sustainable construction, Sustainability strategies.

1. INTRODUCTION

The construction industry is among the largest energy users and carbon producers in the world, and the need to incorporate sustainability concepts in the building industry has

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become not a choice, but a requirement (**Vérez and Cabeza, 2021**). This trend is gaining more relevance in Iraq where there is the need to continue with reconstruction and building of infrastructure as well as the increasing pressure on the environment.

Although there is an increasing interest in the concepts of sustainability, their use in the construction industry is still scarce as there are a number of barriers, the most notable being lack of knowledge, specialized skills and regulatory facilitation. It shows that there is a distinct gap between the theoretical understanding of sustainability and its implementation in the context of Iraq (**Almakayeel et al., 2023; Mohsin and Ellk, 2018**). However, these Iraqi studies addressed specific aspects of sustainability implementation. (**Almakayeel et al., 2023**) focused on modeling implementation barriers in construction projects, whereas (**Mohsin and Ellk, 2018**) examined barriers related to the use of sustainable building materials. In contrast, the present study adopts a broader perspective by simultaneously identifying and prioritizing both sustainability strategies and implementation barriers through a two-round Delphi approach and developing an integrated prioritization framework for the Iraqi construction sector.

The fact that no single vision and a national system that outlines sustainability priorities exist also complicates the issue. This has led to the difference in determining the right strategies and the absence of clarity on the most critical barriers to implementation (**Du Plessis, 2007**). In addition, the interaction of environmental, economic, social, and administrative aspects makes traditional approaches ineffective in understanding this issue fully.

Thus, the Delphi method was implemented in this study as a systematic research method to utilize experts' knowledge and achieve consensus on the most significant sustainable building strategies and their implementation barriers. The research offers a useful model that will help decision-makers to prioritize and justify the implementation of sustainability in the Iraqi construction industry using statistical analysis and professional opinion. The questions which form the basis of the study are as follows:

- What sustainability approaches would best suit the Iraqi construction industry with respect to environmental, economic, social, and administrative aspects?
- What are the most significant obstacles hindering the implementation of these strategies?
- To what extent is there expert consensus on prioritizing these strategies and the obstacles they face?
- How can these results be organized within a framework of priorities that supports decision-making in the Iraqi construction sector?

2. SUSTAINABLE CONSTRUCTION: CONCEPTS, STRATEGIES, AND IMPLEMENTATION BARRIERS

2.1 Concept of Sustainable Construction

Sustainable construction refers to an integrated approach that considers the environmental, economic, and social impacts of construction projects throughout their lifecycle. It goes beyond simply using environmentally friendly materials; it also encompasses efficient resource management, energy conservation, and improved project performance from design to operation (**Kibert, 2016**). Although the terms "green buildings" and "sustainable buildings" are often used interchangeably, they are not identical. Green buildings primarily focus on minimizing environmental impacts through environmentally responsible design



and construction practices. In contrast, sustainable buildings adopt a broader perspective by integrating environmental protection with economic viability and social considerations throughout the building life cycle. Therefore, green buildings represent an important component of sustainable buildings, but the two concepts should not be considered interchangeable **(Al Alwan and Saleh, 2020)**.

Interest in sustainable construction has grown globally due to the direct link between the built environment and energy consumption and carbon emissions. This has led many international initiatives to emphasize the adoption of low-carbon and more resource-efficient construction practices to achieve sustainability goals **(World Green Building Council, 2023)**.

Sustainability in the construction sector is typically viewed through a set of interconnected dimensions that form an integrated framework for evaluating and implementing sustainable practices. This framework is based on the environmental and economic aspects. The former is centered on the reduction of environmental effects whereas the latter is centered on resource efficiency and long term economic viability which encompasses energy efficiency, better utilization of resources, and better performance of the project during its life cycle **(Glavič and Lukman, 2007)**. The social dimension is associated with the enhancement of the quality of life, health and safety, as well as justice in the society, and this is an aspect the construction industry plays in delivering impacts on society that are not necessarily technical and economic **(Vallance et al., 2011)**. The administrative aspect is another influential factor in the implementation of sustainability, as it is related to regulatory and institutional frameworks, management and decision-making processes, and the corresponding policies and standards that influence the project results. The dimension is especially significant in the Iraqi scenario as more organized administration methods are required to facilitate the adoption of sustainable building practices **(Du Plessis, 2007)**.

2.2 Sustainability Strategies in Construction Projects

Sustainability strategies constitute a set of management approaches and planned actions relied on to merge sustainability principles into construction projects throughout their life cycle. These strategies aim to improve project performance by balancing economic feasibility, environmental protection, and social responsibility, while backing long-term development targets **(Du Plessis, 2007)**.

Executing sustainability in the construction sector goes beyond environmental considerations and requires the fostering of multiple managerial, organizational, and technical measures. These measures may involve the ideal use of energy conservation, resources, the chosen of sustainable materials, stakeholder participation, manpower development, and institutional backing mechanisms that facilitate the accomplished of sustainability objectives **(Chan et al., 2017)**.

Prior studies have stressed that the successful implementation of sustainable construction relies on integrated strategies that concurrently address the economic, environmental, social, and administrative dimensions. These strategies can include oversight support, financial incentives, training programs and awareness, technology adoption, and knowledge-sharing initiatives that enhance sustainable decision-making in the construction sector **(Du Plessis, 2007; Chan et al., 2017)**.

Additionally, the identification and prioritization of sustainability strategies can differ depending on localized conditions and sector attributes. Parameters such as technological maturity, institutional capacity, stakeholder recognition, and market circumstance can



remarkably affect sustainability initiatives. Therefore, identifying suitable sustainability strategies for each context is a conclusive step in improving sustainability performance and facilitating the broad adoption of sustainable construction practices (**Botchway et al., 2021**). A recent Iraqi study evaluated and prioritized management and process strategies for integrating sustainability into construction project management using the Kano model and Timko indices. The study identified resource efficiency, construction waste reduction, environmental compliance, and site safety management as high-impact strategies influencing stakeholder satisfaction (**Nasaif and Mahjoob, 2026**). This study provides valuable empirical evidence on the prioritization of management-related sustainability strategies in the Iraqi context. However, its scope was primarily limited to management and process strategies and their effect on stakeholder satisfaction. In contrast, the present study adopts a broader multidimensional perspective by simultaneously examining environmental, economic, social, and administrative strategies together with their implementation barriers. Furthermore, it applies a two-round Delphi method to establish expert consensus and develops an integrated priority framework that combines both sustainability strategies and barriers.

2.3 Barriers to Sustainable Construction in Developing Countries and Iraq

The shift towards sustainable construction is not easy, especially in developing nations, where a set of barriers to practical application exists. The most notable of these barriers include the lack of awareness among stakeholders, high initial cost, and the lack of efficient regulatory frameworks- aspects that undermine the implementation of sustainable practices despite their long-term advantages (**Du Plessis, 2007**).

In Iraq, these issues are exacerbated by the situation in the local construction industry. Recent research has reported that the adoption of green management and sustainable construction practices continues to face significant challenges, particularly those related to financial constraints, inadequate regulatory frameworks, and limited institutional support, which hinder the effective implementation of sustainable practices in the Iraqi construction sector (**Mahjoob et al., 2022**).

2.4 Delphi Method as a Consensus-Building Tool

Delphi method is a systematic method to arrive at consensus among the experts especially when there is limited or no empirical data available. It is based on the experience and professional judgment of experts instead of just on historical data, therefore assisting in making decisions in issues of complexity (**Linstone and Turoff, 2011**).

Initially created by the RAND Corporation to be used in forecasting, the method has since found other applications, in engineering and management research particularly, in solving problems which are uncertain and complex in nature (**Okoli and Pawlowski, 2004**).

The efficiency of the Delphi process is based on a number of important features, the first being the privacy of the opinions of the participants, as it guarantees the independence of judgment; structured feedback, which makes it possible to revise the opinions between the rounds; and the statistical aggregation of the opinions, which makes it possible to reinterpret the qualitative estimates into the quantitative results and analyze them (**Okoli and Pawlowski, 2004**).

The need for such approach is even further supported by sustainability research, due to the interdependency of their environmental, economic, social, and administrative aspects, and



the complexity of the theory-only analysis. Hence expert judgment offers a more appropriate method of prioritizing and determining barriers in a real world application (**Linstone and Turoff, 2011**).

The Delphi method was selected because the study addresses a complex and context-dependent problem for which comprehensive empirical data and an established prioritization framework are still limited in Iraq. The method is particularly suitable for eliciting and refining expert judgments, achieving structured consensus, and reducing the influence of dominant individuals through anonymous and iterative rounds. It also enables the systematic evaluation and prioritization of a large number of sustainability strategies and implementation barriers based on the collective knowledge of experienced professionals. Therefore, the Delphi method was considered appropriate for developing a context-specific and consensus-based prioritization framework for the Iraqi construction sector.

3. RESEARCH METHODOLOGY

3.1 Research Design and Delphi Technique

This paper used a modified Delphi method to investigate the determinants that affect sustainable construction in Iraq. The reason behind this approach is that there is little empirical data concerning green building practices in the local context. In contrast to the conventional approaches to surveys, the Delphi methodology enables the systematic dialogue between specialists and helps to build consensus due to repeated rounds (**Ameyaw et al., 2016**).

This method is especially valuable in reference to this study as it will help fit the globally accepted concepts of sustainability to the regulatory and economic peculiarities of the Iraqi environment and be suitable to the nature of the research issue and its goals (**Noaman and Rezzoqi, 2022**).

3.2 Instrument Development and Variable Identification

The first list of variables was created due to the systematic review of the recent literature, and it led to the identification of 42 sustainability strategies and 24 barriers. The model in the first round of Delphi was an open-ended one, in which the experts could look at the original list and suggest other variables that have a place in the local specific context, based on their professional experience.

The variables that were suggested by the experts were noted in the first round without any quantitative comparison and were put in the second round to be assessed statistically. This method enabled incorporation of variables based on the literature with the ones introduced by the experts in the process of building the consensus.

3.3 Expert Selection and Study Sample

The Delphi approach is mainly based on the expertise of the involved professionals and not on statistical representation. Thus, to choose qualified experts, a purposive sampling approach was chosen, with the choice criteria of the sample based on the selection criteria suggested (**Hallowell and Gambatese, 2010**).



All specialists were obliged to satisfy at least two of the following criteria:

- Minimum 10 years of work experience in the Iraqi construction industry in civil engineering, architecture, or project management.
- A post-graduate degree (Master or PhD) in a sustainability or green building related field.
- One year of work experience in design, construction, or appraisal of large construction projects.

These parameters were used to ensure that the results of the study were founded on expert knowledge that was used on the realities of the practice and local situation.

There is no standard, agreed upon number of Delphi experts, however, past research shows that panel sizes tend to be between 8 and 20 experts. Small-scale studies of construction project management have demonstrated that panels comprising of 8-12 experts can have a high degree of reliable consensus without sacrificing the effectiveness of the iterative process (**Hallowell and Gambatese, 2010**). In line with this, a panel of 16 experts with both academic and professional backgrounds was involved in this study as far as sustainable construction is concerned. This was considered to be a suitable number in order to ensure the credibility of the findings whilst still ensuring that the Delphi rounds were well organized and participated in. Of the 16 experts who participated in the first Delphi round, 14 completed the second round. The second-round panel consisted of the same experts from the original panel, excluding two participants who did not respond to the second-round questionnaire. This attrition was due to non-response rather than exclusion based on the study criteria. Since the stability rates for all dimensions remained below the predefined threshold (15%), and the consensus measures indicated satisfactory agreement, the reduction in panel size was not considered to have materially affected the reliability or stability of the Delphi results.

3.4 Identifying Sustainability Strategies and Barriers

The recognition of sustainability strategies and barriers was made after conducting a thorough survey of the existing literature, with emphasis on research that covered sustainable building practices in the international arena and developing nations. The outcome of this review was a preliminary list of variables that capture the most important factors that affect the application of sustainability in the construction industry.

Each variable was coded to be used to process and organize it during the Delphi rounds. The original list comprised 42 strategies and 24 barriers, which were put in the first round whereby they were evaluated and refined by experts.

The variables were introduced as per their different dimensions and each of the dimensions was introduced in separate tables with the sustainability strategies and the barriers respectively thereby providing a clear presentation and consistency in the analysis.

3.4.1 Environmental Dimension

The environmental dimension entails several strategies intended to minimize environmental impacts that are balanced by a series of barriers that might hinder their successful implementation in construction projects as illustrated in **Tables 1 and 2**.

**Table 1.** Environmental sustainability strategies in the construction sector

CODE	Environmental Strategies	References
SE1	Use passive design (building orientation, natural ventilation) to minimize energy consumption.	(Yin et al., 2020; U.S. Green Building Council, 2019)
SE2	Use high-efficiency, energy-saving HVAC systems.	(Olubunmi et al., 2022)
SE3	Rely on on-site renewable energy sources (such as photovoltaic solar panels).	(Kibert, 2016)
SE4	Use high-performance glass and windows (double/triple)	(Al-Sari et al., 2020)
SE5	Install low-flow sanitary water fittings	(Fei et al., 2021)
SE6	Treat and reuse greywater or rainwater for irrigation.	(Ghisellini et al., 2018; U.S. Green Building Council, 2019)
SE7	Use building materials with recycled content, such as	(Benachio et al., 2020)
SE8	Use environmentally friendly building materials with an Environmental Product Declaration (EPD).	(BRE Global, 2018; U.S. Green Building Council, 2019)
SE9	Implement a strict on-site construction waste management plan (sorting, recycling).	(Kabirifar et al., 2020)
SE10	Choose a project site away from environmentally	(U.S. Green Building Council, 2019)
SE11	Redevelop previously damaged sites (brownfields)	(U.S. Green Building Council, 2019)
SE12	Minimize the "heat island" effect by using heat-reflective roofs and landscaping.	(Wang et al., 2022)
SE13	Prevent soil and groundwater contamination during excavation and construction (erosion control).	(U.S. Environmental Protection Agency, 2022; Al-Sari, 2020)
SE14	Reduce nighttime light pollution from the project site or building.	(U.S. Green Building Council, 2019)
SE15	Use FSC-certified wood from sustainable forests.	(Forest Stewardship Council, 2020)

Table 2. Environmental Sustainability Barriers in the Construction Sector

CODE	Environmental Barriers	References
BE1	Lack of advanced technology and equipment necessary for implementing smart green buildings.	(Ahn et al., 2013)
BE2	Absence of accredited laboratories and official bodies to test the quality of sustainable materials.	(Hwang and Tan, 2012; Chan et al., 2018)
BE3	Harsh climatic conditions (high temperatures, dust storms) affect the sustainability of environmental technologies.	(Radhi, 2011; Chaichan et al, 2023)
BE4	Lack of reliable data and information on the environmental performance of local materials.	(Du Plessis, 2007)
BE5	Complexity and difficulty in maintaining sustainable systems (such as solar panels) in the local environment.	(Ali and Al Nsairat, 2009)

3.4.2 Economical Dimension

The economic dimension talks about cost-effectiveness and lifecycle performance, as well as the financial limits that make it hard to adopt sustainable practices, as seen in **Tables 3 and 4.**

**Table 3.** Economic sustainability strategies in the construction sector

CODE	Economical Strategies	References
SC1	Implementing Lifecycle Cost Analysis (LCC) instead of relying on the lowest initial price.	(Higham et al., 2020)
SC2	Utilizing prefabricated/modular construction techniques for faster completion and reduced costs.	(Wuni and Shen, 2020)
SC3	Purchasing building materials from local suppliers to minimize transportation costs.	(Kibert, 2016)
SC4	Designing for disassembly to sell materials for scrap in the future.	(Benachio et al., 2020)
SC5	Selecting durable materials to reduce maintenance and replacement expenses.	(Kibert, 2016)
SC6	Utilizing smart metering systems to monitor and reduce operating costs.	(U.S. Green Building Council, 2019)
SC7	Applying Lean Construction principles to minimize financial and time waste.	(Francis and Thomas, 2020)
SC8	Design flexibility to facilitate future changes to the building's function at minimal cost.	(Kibert, 2016)
SC9	Improving the supply chain to ensure material availability and reduce the risk of project delays.	(Zhu and Sarkis, 2021)
SC10	Utilizing Building Information Modeling (BIM) to minimize change orders and rework.	(Love et al., 2014)

Table 4. Economic sustainability barriers in the construction sector

CODE	Economical Barriers	References
BC1	The significant increase in initial design and construction costs compared to traditional construction.	(Dwaikat and Ali, 2016; Robichaud and Anantamula, 2011)
BC2	The absence of financial support, green loans, and tax incentives from the government.	(Chan et al., 2018; Bond, 2011)
BC3	The long payback period for energy-efficient technologies.	(Kibert, 2016)
BC4	The risks of investing in new technologies that are not widely tested in the Iraqi market.	(Zhang et al., 2011; Al-Hashimi, 2020)
BC5	The volatility of exchange rates and its impact on the cost of importing technological materials.	(Muhammed and Adindu, 2021)
BC6	The lack of research and development (R&D) budgets in construction companies.	(Ofori-Kuragu et al., 2016)

3.4.3 Social Dimension

The social dimension looks at how projects affect society and the well-being of users, as well as the problems that come up with raising awareness and implementing sustainable practices, as seen in **Tables 5 and 6**.

**Table 5.** Social sustainability strategies in the construction sector

CODE	Social Strategies	References
SS1	Implementing a rigorous Occupational Health and Safety (OHS) plan to protect workers.	(Zuo et al., 2020)
SS2	Providing high indoor air quality (IAQ) and using low-emission materials.	(Wei et al., 2020)
SS3	Ensuring thermal and visual comfort (natural lighting) for building occupants.	(Kibert, 2016)
SS4	Providing a suitable acoustic environment (noise insulation) within the building.	(BRE Global, 2018)
SS5	Employing and training local workers to enhance the local community's capabilities.	(Stanitsas et al., 2021)
SS6	Effective communication with the surrounding community to minimize construction disturbances (noise/dust).	(Nawaz et al., 2021)
SS7	Incorporating universal design to serve people with disabilities and the elderly.	(U.S. Department of Justice, 2010; U.S. Green Building Council, 2019)
SS8	Preserving the architectural and heritage identity of the area in the project design.	(Foster, 2020)
SS9	Providing suitable service and recreational facilities for workers on the construction site.	(Stanitsas et al., 2021)
SS10	Providing views to the outside for most building occupants to promote mental well-being.	(Vallance et al., 2011)
SS11	Enhancing social security in the design (lighting, surveillance) to prevent crime.	(BRE Global, 2018)

Table 6. Social Barriers to Sustainable Construction

CODE	Social Barriers	References
BS1	Lack of awareness and knowledge of the concept and benefits of sustainability among owners and end-users.	(Zainul Abidin, 2010; Bond, 2011)
BS2	Cultural resistance and adherence to traditional architectural and construction styles.	(Williams and Dair, 2007)
BS3	The prevailing perception that sustainable buildings are merely an expensive "luxury" rather than a necessity.	(Chan et al., 2018; Shrestha and Pushpala, 2012)
BS4	Weak attention to social and environmental responsibility among contractors and employers.	(Bond, 2011; Domínguez-Herrera et al., 2023)
BS5	Inadequate alignment of university curricula and union programs with rapid advancements in sustainability technologies.	(Gou et al., 2013)
BS6	Reluctance of users to modify their daily behaviors to conform to sustainable building systems.	(Owens and Drifill, 2008; He et al., 2018)

3.4.4 Administrative Dimension

The administrative dimension looks at the role of policies and regulatory frameworks, as well as the institutional barriers that make it hard to put sustainability practices into action, as shown in **Tables 7 and 8**.

**Table 7.** Administrative sustainability strategies in the construction sector

CODE	Institutional and Managerial Strategies	References
SM1	Clearly integrate sustainability requirements into tender documents and contracts.	(Samari et al., 2013)
SM2	Appoint a sustainability specialist or consultant to the project management team.	(Project Management Institute, 2021)
SM3	Conduct advanced commissioning of systems prior to handover.	(ASHRAE, 2018; U.S. Green Building Council, 2019)
SM4	Digitalize project documentation and minimize on-site paperwork.	(Botchway et al., 2021)
SM5	Adopt a global sustainability rating system (LEED/BREEAM) as a strategic project objective.	(U.S. Green Building Council, 2019; BRE Global, 2018)
SM6	Engage all stakeholders (owner, designer, contractor) early (Integrated Delivery).	(Kineber et al., 2021)

Table 8. Administrative barriers to sustainable construction

CODE	Institutional and Managerial Barriers	References
BM1	The absence of legislation, laws, and local engineering codes that mandate sustainability.	(Du Plessis, 2007)
BM2	Overlapping jurisdictions and complex administrative procedures in obtaining approvals for green projects.	(Samari et al., 2013)
BM3	A shortage of qualified engineers and skilled labor experienced in managing sustainability projects.	(Shi et al., 2013 ; Durdyev et al., 2018)
BM4	Weak government oversight of sustainability standards during project implementation.	(Durdyev et al., 2018)
BM5	The inadequacy of traditional contract models in addressing the requirements and risks of sustainable construction.	(Hwang et al., 2015)
BM6	Poor coordination between government agencies and the private sector in developing sustainability policies.	(Ofori, 2015; Yang and Yang, 2015)
BM7	Outdated General Technical Specifications (GTS) and a lack of updates to incorporate green technologies.	Du Plessis, 2007)

3.5 Delphi Rounds

The Delphi process was done in two consecutive rounds in order to achieve consensus by the experts involved. In the first stage, the initial list of sustainability strategies and their constraints was presented to the experts for assessment. They were meant, based on their knowledge of the topic, to assess how relevant the proposed variables might be, and recommend variables relevant to a specific local situation. In this stage, the data regarding the new proposed variables were collected without being subject to any quantitative evaluation. During round two, the updated list of variables, using variables from the literature and variables proposed by the experts, was redistributed for quantitative evaluation. The experts provided a structured scale for estimating the relative importance of the various variables, allowing for the conversion of their judgments into data that could be analyzed, compared, and prioritized. Again, the Delphi approach allows for the opinions to be reviewed in accordance with the feedback received, which improves the reliability of the results and provides a wider consensus for the panel members.



3.6 Data Analysis

Using descriptive and inferential statistical methods, data collected from the Delphi rounds was analyzed to assess the significance of the variables, measure the level of concordance, and verify the stability of the expert responses. Data analysis was conducted in SPSS (version 26) and Microsoft Excel (2024).

3.6.1 Measuring Relative Importance

Each strategy and constraint's relative importance was calculated using a weighted average on a five-point Likert scale; variables with higher averages were considered more important. This is a common practice in sustainable building studies (**Mansor and Mohammed, 2015**). Standard deviation was also calculated to measure the dispersion of responses, with lower values indicating less variability among expert ratings (**Henning and Jordaan, 2016**).

3.6.2 Measures of Consensus

To evaluate the level of agreement among experts, the coefficient of variation (CV) was used as a primary indicator of consensus. The CV measures the relative dispersion of responses in relation to the mean and is expressed as Eq. (1):

$$CV = \frac{\sigma}{x} \quad (1)$$

Where: σ represents standard deviation, and x represents the mean

Lower CV values indicate stronger agreement among experts. In this study, a threshold of $CV \leq 0.5$ was adopted to indicate an acceptable degree of consensus, consistent with previous Delphi research (**Henning and Jordaan, 2016**).

3.6.3 Acceptance Criteria

The study adopted a set of rules for judging the acceptance or rejection of variables. A strategy or obstacle was considered acceptable if it met the following two conditions:

- Weighted mean ≥ 3.5
- Coefficient of variation ($CV \leq 0.5$)

This dual criterion aims to retain variables that combine relative importance with an acceptable level of consensus among experts (**Ameyaw et al., 2016; Henning and Jordaan, 2016**).

3.6.4 Stability of Responses

The stability of expert responses between the first and second rounds of Delphi was assessed based on the percentage change in arithmetic means, which was calculated according to Eq. (2):

$$\text{Stability} = \frac{|Mean R2 - Mean R1|}{Mean R1} \times 100 \quad (2)$$

The stability of expert responses was assessed based on the percentage change in arithmetic means between successive Delphi rounds (**Dajani et al., 1979**). A change rate of less than 15% was adopted as the criterion for stability, following previous Delphi studies.



3.6.5 Statistical Significance of Concordance

The Kendall concordance coefficient (W) was used to measure the overall level of agreement among experts in the arrangement of variables. The coefficient ranges from 0 to 1, with higher values indicating a stronger level of concordance. To verify the statistical significance of this concordance, the chi-square test was used. Concordance was considered statistically significant when the p-value was less than 0.05, indicating that the concordance was not due to chance (Siegel and Castellan, 1988; Schmidt, 1997).

3.6.6 Revising the Variables Proposed by Experts

The additional strategies and constraints proposed by experts in the first Delphi round underwent review and refinement. This included removing duplicate items, verifying their consistency with the adopted sustainability dimensions, and reformulating them into more measurable and standardized terms. Following this revision, these variables were included in the second round for quantitative evaluation, allowing for the inclusion of both literature-derived and expert-proposed variables in the final analysis.

4. RESULTS AND DISCUSSION

4.1 Expert Panel Characteristics

Among those in the first round of Delphi, 16 participated. The sample had some good diversity in such things as academic qualifications, experience, and specialty, suggesting that the opinions presented were well-informed and based on diverse professional perspectives. **Table 9** shows that 50% of participants had a bachelor's degree, 25% a master's degree, and 25% a doctorate; as a result, the participants had a well-balanced education. As for professional experience, **Table 10** suggests that 50% of experts have more than 20 years of experience, 31.3% have between 10 and 15 years of experience and 18.8% have between 16 and 20 years of experience, demonstrating a high level of expertise in the construction field. Regarding knowledge of sustainable building concepts, a good level or even high one can be reached **Table 11**. 50% were good-knowledge's, 18.8 % were expert, 6.3% had advanced knowledge, and 25% had general awareness. **Table 12** also indicates how differently participants use sustainability practices with 50% reporting that sustainability practices are frequently used, 37.5% reporting that they use them sporadically, and 12.5% reporting that they rarely use it. **Table 13** reveals that 62.5% of experts have training/professional certificates for specialist knowledge of sustainability as compared to 37.5% who have not, to augment the credibility of the committee results. With regard to professional positions, **Table 14** depicts the variety of participants in profession. 37.5% were academics and researchers, 25% were consultant; senior site engineers/project managers, each at 18.8%, indicating a mix of educational and practical experience.

Table 9. Education

Education	Frequency	Percentage %
Bachelor	8	50
Master	4	25
PhD	4	25
Total	16	100

Table 10. Experience

Experience	Frequency	Percentage %
(10-15) year	5	31.3
(16-20) year	3	18.8
More 20 year	8	50
Total	16	100

**Table 11.** Knowledge

Knowledge	Frequency	Percentage %
General Awareness	4	25
Good Knowledge	8	50
Advanced Knowledge	1	6.3
Expert	3	18.8
Total	16	100

Table 12. Practice

Practice	Frequency	Percentage %
Rarely	2	12.5
Sometimes	6	37.5
Often	8	50
Total	16	100

Table 13. Training

Training	Frequency	Percentage %
Received Training	10	62.5
No Formal Training	6	37.5
Total	16	100

Table 14. Job Position

Job Position	Frequency	Percentage %
Senior Site Engineer	3	18.8
Consultant Engineer	4	25
Project Manager	3	18.8
Academic/Researcher	6	37.5
Total	16	100

4.2 Results of Sustainability Strategies and Barriers

This section presents the results of the Delphi study on sustainability strategies and their obstacles across four dimensions: environmental, economic, social, and administrative, based on the results of the first and second rounds. The results include the weighted means for both rounds, while the standard deviation and coefficient of variation (CV) for the second round are presented to measure the level of agreement among experts. The variables were ranked in descending order according to the weighted mean in the second round, and only the strategies and obstacles that met the specified acceptance criteria, a weighted mean ≥ 3.5 and a coefficient of variation ≤ 0.5 were included in the subsequent analysis.

4.2.1 Environmental Dimension

4.2.1.1 Environmental Dimension Strategies

Environmental sustainability strategies are presented in **Table 15**, ranked according to the weighted averages obtained from the second round of the Delphi study. High-efficiency air conditioning systems (SE2) ranked first, followed by passive design strategies (SE1), the use of on-site renewable energy sources (SE3), and high-performance building envelope systems (SE4), indicating that experts placed greater emphasis on improving energy efficiency as a primary approach to enhancing environmental sustainability. In contrast, six strategies did not meet the predefined acceptance criteria and were therefore excluded from the final framework. The prioritization of energy-efficient strategies indicates that experts consider reducing energy consumption the most practical approach to improving environmental sustainability in Iraqi construction projects. This finding is consistent with (Ahn et al., 2013), who identified energy conservation as one of the most important drivers of sustainable design and construction practices, and with (Ali and Al Nasairat, 2009), who identified energy efficiency, renewable energy integration, and high-performance building envelopes as essential elements of green building assessment systems for developing countries. In contrast, strategies related to recycled materials and low-carbon construction alternatives received lower ratings, which may reflect implementation challenges, limited availability of green materials, and market constraints commonly encountered in developing countries, as also reported by (Aghimien et al., 2018).

**Table 15.** Results of Delphi evaluation for environmental sustainability strategies

COD E	Strategies	M1	M2	S. D.	CV	Final Decision
SE2	Use high-efficiency, energy-saving HVAC systems.	4.06	4.29	0.73	0.169	Accepted
SE1	Use passive design (building orientation, natural ventilation) to minimize energy consumption.	3.88	4.21	0.80	0.190	Accepted
SE3	Rely on on-site renewable energy sources (such as photovoltaic solar panels).	4	4.21	0.89	0.212	Accepted
SE4	Use high-performance glass and windows (double/triple insulation) to minimize heat gain.	3.94	4.21	0.70	0.166	Accepted
SE9	Implement a strict on-site construction waste management plan (sorting, recycling).	3.25	3.79	0.89	0.236	Accepted
SE8	Use environmentally friendly building materials with an Environmental Product Declaration (EPD).	3.31	3.71	0.99	0.268	Accepted
SE12	Minimize the "heat island" effect by using heat-reflective roofs and landscaping.	3.56	3.71	0.91	0.246	Accepted
SE6	Treat and reuse greywater or rainwater for irrigation.	3.38	3.64	1.15	0.316	Accepted
SE13	Prevent soil and groundwater contamination during excavation and construction (erosion control).	3.56	3.64	0.93	0.255	Accepted
SE17	Providing waste sorting systems at the source and allocating containers for recycling.	----	3.64	0.84	0.231	Accepted
SE5	Install low-flow sanitary water fittings (sensors/measures) to reduce consumption.	3.56	3.50	0.76	0.217	Accepted
SE7	Use building materials with recycled content, such as steel/concrete.	3.13	3.43	0.94	0.273	Rejected
SE10	Choose a project site away from environmentally sensitive areas or agricultural land.	3.25	3.43	0.94	0.273	Rejected
SE16	Adopting low-carbon construction alternatives to reduce cement use	-----	3.36	0.93	0.277	Rejected
SE14	Reducing nighttime light pollution from the project site or building.	3.13	3.14	0.86	0.275	Rejected
SE11	Redevelop previously damaged sites (brownfields) instead of building on virgin land.	3	3.00	0.78	0.261	Rejected
SE15	Using FSC-certified wood from sustainable forests.	2.44	2.50	1.16	0.464	Rejected
		3.6	3.73	3.72 %		

4.2.1.2 Environmental Dimension Barriers

The environmental dimension barriers are presented in Table 16, ranked according to the weighted averages from the second round of the Delphi study. Lack of advanced technology and equipment (BE1) was identified as the most significant barrier, followed by the absence of accredited laboratories for testing sustainable materials (BE2) and the limited availability of sustainable materials in the local market (BE6). These findings indicate that technical limitations and insufficient supporting infrastructure remain the primary challenges to implementing environmental sustainability practices in the Iraqi construction sector.

The findings suggest that environmental sustainability in Iraqi construction projects is constrained mainly by technical and infrastructure-related barriers. The high ranking of inadequate technology, the absence of accredited testing laboratories, and the limited availability of sustainable materials are consistent with (Aghimien et al., 2018), who identified limited technical support and market readiness as major barriers to sustainable

construction. Similar challenges were also highlighted by (Mahjoob et al., 2022) in the Iraqi construction sector.

Table 16. Results of Delphi Evaluation for Environmental Sustainability Barriers

CODE	Barriers	M1	M2	S. D.	CV	Final Decision
BE1	Lack of advanced technology and equipment necessary for implementing smart and green buildings.	4.13	4.29	0.73	0.169	Accepted
BE2	Absence of accredited laboratories and official bodies to test the quality of sustainable materials .	4.13	4.14	0.66	0.160	Accepted
BE6	Limited availability of sustainable and recycled building materials in the local market.	----	3.93	0.62	0.157	Accepted
BE3	Harsh climatic conditions (high temperatures, dust storms) affect the sustainability of environmental technologies.	3.75	3.79	0.70	0.185	Accepted
BE4	Lack of reliable data and information on the environmental performance of local materials.	3.75	3.79	0.89	0.236	Accepted
BE5	Complexity and difficulty in maintaining sustainable systems (such as solar panels) in the local environment.	3.56	3.43	0.85	0.248	Rejected
		3.94	3.99	1.16%		

4.2.2 Economic Dimension

4.2.2.1 Economic Dimension Strategies

The economic dimension strategies are shown in **Table 17** based on their weighted average across the second round of the Delphi assessment. This means that the strategy of buying building materials from local suppliers (SC3) ranked first, with an average of 4.43 (indicating that it reduces transportation costs and enhances economic efficiency). After that, the strategy of selecting durable materials (SC5) was followed by prefabricated building technologies (SC2), which were also categorized among the highly important strategies. On the other hand, two strategies were rejected for not reaching the acceptance criteria. The findings indicate that experts prioritized practical strategies that improve economic efficiency while reducing long-term costs. This is consistent with (Ahn et al., 2013), who emphasized life-cycle value and resource efficiency, and with (Mahjoob et al., 2022), who highlighted the importance of cost-efficient practices in the Iraqi construction sector.

4.2.2.2 Economic Dimension Barriers

Table 18 shows the economic dimension barriers, which are ranked by the weighted averages from the second round of Delphi. The shortfall in research and development budgets (BC6) and the risks of investing in untested technologies (BC4) were the biggest problems, each getting an average score of 4.21. This reflects a state of financial uncertainty and weak innovation capacity in the construction sector.

These were followed by barriers related to the absence of financial support mechanisms, such as green loans and tax incentives (BC2), as well as the high initial costs of sustainable construction (BC1), which also registered high levels of importance.



It is also worth noting that barriers (BC7) were added in the second round and underwent direct evaluation by experts. This reflects the importance of the Delphi method in identifying Barriers related to the local context that were not included in the initial list.

Table 17. Results of Delphi evaluation for economic sustainability strategies.

CODE	Strategies	M1	M2	S. D.	CV	Final Decision
SC3	Purchasing building materials from local suppliers to minimize transportation costs.	4.19	4.43	0.76	0.171	Accepted
SC5	Selecting durable materials to reduce maintenance and replacement expenses.	4.06	3.86	0.77	0.200	Accepted
SC2	Utilizing prefabricated/modular construction techniques for faster completion and reduced costs.	3.44	3.79	0.70	0.185	Accepted
SC1	Implementing Lifecycle Cost Analysis (LCC) instead of relying on the lowest initial price.	3.38	3.79	0.97	0.258	Accepted
SC6	Utilizing smart metering systems to monitor and reduce operating costs.	3.69	3.64	0.50	0.136	Accepted
SC10	Utilizing Building Information Modeling (BIM) to minimize change orders and rework.	3.88	3.64	1.01	0.277	Accepted
SC7	Applying Lean Construction principles to minimize financial and time waste.	3.56	3.50	0.76	0.217	Accepted
SC8	Design flexibility to facilitate future changes to the building's function at minimal cost.	3.69	3.50	1.16	0.331	Accepted
SC9	Improving the supply chain to ensure material availability and reduce the risk of project delays.	3.5	3.43	1.16	0.338	Rejected
SC4	Designing for disassembly to sell materials for scrap in the future.	3.13	3.00	0.78	0.261	Rejected
		3.65	3.66	0.14%		

Table 18. Results of Delphi Evaluation for Economic Sustainability Barriers

CODE	Barriers	M1	M2	S. D.	CV	Final Decision
BC6	The lack of research and development (R&D) budgets in construction companies.	4.31	4.21	0.80	0.190	Accepted
BC4	The risks of investing in new technologies that are not widely tested in the Iraqi market.	4	4.21	0.89	0.212	Accepted
BC1	The significant increase in initial design and construction costs compared to traditional construction.	3.75	4.14	1.10	0.265	Accepted
BC2	The absence of financial support, green loans, and tax incentives from the government.	3.88	4.14	0.77	0.186	Accepted
BC5	The volatility of exchange rates and its impact on the cost of importing technological materials.	3.94	4.07	1.14	0.280	Accepted
BC3	The long payback period for energy-efficient technologies.	3.81	3.93	0.92	0.233	Accepted
BC7	The high operational costs associated with providing decent living conditions and housing for workers on construction sites.	---	3.64	0.63	0.174	Accepted
		4.03	4.18	3.69%		

The findings suggest that limited investment in innovation, inadequate financial support, and high implementation costs remain the main economic barriers to sustainable construction. Similar barriers, including limited funding, lack of financial incentives, and high implementation costs, were reported by (Aghimien et al., 2018). Likewise, (Mahjoob et al., 2022) identified financial constraints and limited investment in green technologies as major challenges in the Iraqi construction sector.

4.2.3 Social Dimension

4.2.3.1 Social Dimension Strategies

The social dimension strategies are presented in **Table 19**, ranked according to the weighted averages from the second round of the Delphi assessment.

The strategy of implementing a rigorous occupational health and safety plan (SS1) ranked first with an average of (4.57), followed by the strategy of providing high indoor air quality and using low-emission materials (SS2), and then ensuring thermal and visual comfort for building occupants (SS3). The strategies for training local staff (SS5) and providing a suitable acoustic environment within the building (SS4) also achieved high levels of importance among the evaluated strategies.

Table 19. Results of Delphi Evaluation for Social Sustainability Strategies

CODE	Strategies	M1	M2	S. D.	CV	Final Decision
SS1	Implementing a rigorous Occupational Health and Safety (OHS) plan to protect workers.	4.38	4.57	0.76	0.165	Accepted
SS2	Providing high indoor air quality (IAQ) and using low-emission materials.	4	4.36	0.84	0.193	Accepted
SS3	Ensuring thermal and visual comfort (natural lighting) for building occupants.	4	4.07	0.73	0.179	Accepted
SS5	Employing and training local workers to enhance the local community's capabilities.	4.13	4.07	0.62	0.151	Accepted
SS4	Providing a suitable acoustic environment (noise insulation) within the building.	4	4.07	0.83	0.204	Accepted
SS7	Incorporating universal design to serve people with disabilities and the elderly.	3.56	3.64	0.93	0.255	Accepted
SS11	Enhancing social security in the design (lighting, surveillance) to prevent crime.	3.88	3.64	0.93	0.255	Accepted
SS9	Providing suitable service and recreational facilities for workers on the construction site.	3.5	3.57	0.65	0.181	Accepted
SS12	Developing educational curricula and training programs to integrate sustainability concepts and applications into engineering education.	----	3.57	0.76	0.212	Accepted
SS8	Preserving the architectural and heritage identity of the area in the project design.	3.44	3.50	1.02	0.291	Accepted
SS6	Effective communication with the surrounding community to minimize construction disturbances (noise/dust).	3.63	3.36	0.74	0.222	Rejected
SS10	Providing views to the outside for most building occupants to promote mental well-being.	3.44	3.36	1.15	0.343	Rejected
		3.81	3.84	0.61%		



The findings indicate that experts prioritized strategies that enhance workers' safety, occupants' well-being, and local capacity development. This is consistent with (Ahn et al., 2013), who emphasized healthy indoor environments and occupant well-being as key components of sustainable buildings. Similarly, (Mahjoob et al., 2022) highlighted the importance of workforce development and improving working conditions to support sustainable construction practices in Iraq.

4.2.3.2 Social Dimension Barriers

The social dimension barriers are presented in **Table 20**, ranked according to the weighted averages from the second round of the Delphi assessment.

Table 20. Results of Delphi evaluation for social sustainability barriers

CODE	Barriers	M1	M2	S. D.	CV	Final Decision
BS1	Lack of awareness and knowledge of the concept and benefits of sustainability among owners and end-users.	4.38	4.57	0.76	0.165	Accepted
BS4	Weak attention to social and environmental responsibility among contractors and employers.	4.19	4.29	0.83	0.193	Accepted
BS5	Inadequate alignment of university curricula and union programs with the rapid advancements in sustainability technologies.	4.06	4.07	0.83	0.204	Accepted
BS3	The prevailing perception that sustainable buildings are merely an expensive "luxury" rather than a necessity.	3.88	3.93	0.73	0.186	Accepted
BS2	Cultural resistance and adherence to traditional architectural and construction styles.	3.75	3.93	0.83	0.211	Accepted
BS10	Lack of a culture of full compliance with occupational safety standards and the use of personal protective equipment at construction sites.	----	3.93	0.83	0.211	Accepted
BS7	A decline in environmental priorities within the community culture compared to immediate economic demands.	----	3.79	0.89	0.236	Accepted
BS8	Limited environmental awareness and culture among engineering staff and workers at construction sites.	----	3.71	0.91	0.246	Accepted
BS6	Reluctance of users to modify their daily behaviors to conform to sustainable building systems.	3.75	3.43	0.65	0.188	Rejected
BS11	Weak public awareness of the health and environmental risks resulting from neglecting sustainability standards in construction.	----	3.43	1.02	0.296	Rejected
BS9	Absence of ongoing media and educational programs to instill a culture of environmental conservation within the community.	----	3.36	0.63	0.189	Rejected
		4	4.04	0.85%		

For this, unawareness and misunderstanding of sustainability concepts emerged as the major barrier (BS1) - measured with an average of (4.57). Following this up was disinterest in social and environmental responsibility among stakeholders (BS4), which was complemented by inadequate educational curricula with respect to sustainability developments (BS5). Similar barriers were identified in high levels among other factors — perception of sustainability as a luxury (BS3), resistance to traditional patterns (BS2), a

weak culture of commitment to occupational safety standards (BS10), a decline in the societal priority given to environmental issues (BS7), and limited environmental awareness among engineers and workers at work sites (BS8). Three barriers did not meet the acceptance criteria mentioned and therefore were not included in the final results. The findings indicate that social barriers extend beyond technical issues to include limited sustainability awareness, weak educational support, and insufficient stakeholder commitment. Similar barriers, including inadequate knowledge, limited stakeholder engagement, and weak institutional capacity, were reported by (Aghimien et al., 2018; Mahjoob et al., 2022), highlighting the importance of strengthening sustainability education and awareness programs.

4.2.4 Administrative Dimension

4.2.4.1 Administrative Dimension Strategies

Table 21 shows the administrative sustainability strategies, which are ranked based on the weighted averages from the second round of the Delphi assessment. Integrating sustainability requirements into tender and contract documents (SM1) ranked first with an average of 4.29, followed by appointing a sustainability specialist to the project team (SM2). This reflects the importance of governance and structured management in supporting the implementation of sustainability practices. Other strategies, such as digitizing project documents (SM4) and adopting sustainability assessment systems (SM5), also demonstrated significant importance among experts.

Table 21. Results of Delphi evaluation for administrative sustainability strategies

CODE	Strategies	M 1	M 2	S. D.	CV	Final Decision
SM1	Clearly integrate sustainability requirements into tender documents and contracts.	4.06	4.29	0.73	0.169	Accepted
SM2	Appoint a sustainability specialist or consultant to the project management team.	3.63	4.07	0.92	0.225	Accepted
SM4	Digitalize project documentation and minimize on-site paperwork.	3.81	3.86	0.77	0.200	Accepted
SM5	Adopt a global sustainability rating system (LEED/BREEAM) as a strategic project objective.	3.38	3.79	0.97	0.258	Accepted
SM6	Engage all stakeholders (owner, designer, contractor) early (Integrated Delivery).	3.5	3.79	0.70	0.185	Accepted
SM3	Conduct advanced commissioning of systems prior to handover.	3.63	3.71	0.47	0.126	Accepted
SM7	Developing educational curricula and training programs to integrate sustainability concepts and applications into engineering education.	-----	3.71	0.83	0.222	Accepted
		3.67	3.92	6.77%		

The findings indicate that experts prioritized governance-oriented strategies, particularly integrating sustainability requirements into contracts and strengthening project management capabilities. Similar priorities were reported by (Almakayeel et al., 2023), who emphasized the importance of management commitment and structured sustainability practices. Likewise, (Ahn et al., 2013) highlighted the role of sustainability assessment systems and effective project management in supporting sustainable construction implementation.



4.2.4.2 Administrative Dimension Barriers

The administrative dimension barriers are presented in **Table 22**, ranked according to the weighted averages of the second round of the Delphi test. Weak government oversight of sustainability standards (BM4) emerged as the most significant barrier, with an average of (4.36). This was followed by the absence of clear legislation and binding local codes on sustainability (BM1), as well as administrative complexity and overlapping jurisdictions among stakeholders (BM2).

Table 22. Results of Delphi evaluation for administrative sustainability barriers

CODE	Barriers	M1	M2	S. D.	CV	Final Decision
BM4	Weak government oversight of sustainability standards during project implementation.	4.38	4.36	0.74	0.171	Accepted
BM1	The absence of legislation, laws, and local engineering codes that mandate sustainability.	3.94	4.29	0.83	0.193	Accepted
BM2	Overlapping jurisdictions and complex administrative procedures in obtaining approvals for green projects.	4.13	4.21	0.70	0.166	Accepted
BM3	A shortage of qualified engineers and skilled labor experienced in managing sustainability projects.	4.19	4.07	0.83	0.204	Accepted
BM6	Poor coordination between government agencies and the private sector in developing sustainability policies.	4.06	4.07	0.62	0.151	Accepted
BM5	The inadequacy of traditional contract models in addressing the requirements and risks of sustainable construction.	4.06	3.93	0.92	0.233	Accepted
BM8	The absence of incentives and recognition for pioneering projects that achieve high sustainability standards.	----	3.93	0.73	0.186	Accepted
BM9	Weak technical auditing standards in municipalities when granting building permits for buildings that do not comply with insulation requirements.	---	3.79	0.97	0.258	Accepted
BM10	The lack of procedural facilitations and government incentives to support the import and distribution of environmentally friendly construction materials.	----	3.79	0.97	0.258	Accepted
BM11	Weak legal frameworks and deterrent penalties against those who cause pollution or violate environmental standards.	----	3.71	0.73	0.196	Accepted
BM12	Neglecting the periodic and preventive maintenance plans necessary to sustain the efficiency of environmental and smart systems.	----	3.64	0.63	0.174	Accepted
BM7	Outdated General Technical Specifications (GTS) and a lack of updates to incorporate green technologies.	3.44	3.57	0.51	0.144	Accepted
		4.0286	4.07	1.06%		



Other barriers, such as a shortage of qualified personnel (BM3) and weak coordination between the public and private sectors (BM6), also demonstrated high levels of importance among experts. During the Delphi rounds, several more barriers were found. This shows that the experts' job was to find institutional and contextual problems that weren't fully represented in the first list. The findings indicate that administrative barriers are primarily associated with weak institutional governance, inadequate legislation, and limited government support. Similar challenges were reported by (Almakayeel et al., 2023), who emphasized the importance of regulatory frameworks and institutional commitment for sustainable construction. Likewise, (Aghimien et al., 2018) identified inadequate government policies and the lack of regulatory support as major barriers to sustainability implementation.

4.3 Consensus and Stability Analysis

Consistency and stability were calculated to analyze the reliability of the Delphi results in **Table 23**. Based on percentage change in the mean values of common variables between rounds, the stability result demonstrated that all dimensions reached stable values (between 0.14% to 3.72%). This shows that expert opinions have a stable interpretation, removing a need for repeated rounds of Delphi (Dajani et al., 1979). As for consistency, Kendall's W-value indicates some of the axes are not consistent. The consistency was moderate (0.288) on environmental dimension strategies and 0.235 on social dimension strategies, while relatively lower levels of consistency were recorded for the constraints on the economic dimension (0.074) and some administrative dimension strategies including the administrative dimension strategies (0.09), which is somewhat consistent. Variation of this nature is acceptable in sustainability research, in particular, within the context of other contexts, since some economic and institutional conditions are also influenced by a variety among professional experiences and the local context. Agreement between the axes was also variable in terms of statistical significance. Some axes reached statistical significance ($p < 0.05$) but only a few did not, for those that were the obstacles in the economic dimension ($p = 0.396$), strategies in the administrative dimension ($p = 0.279$) and obstacles in the administrative dimension ($p = 0.056$). This variation may be attributed to differences in the Iraqi economic and institutional environment, which are reflected in the experts' professional experiences and judgments. Similarly, the environmental and social axes, with comparatively high chi-square values, showed a stronger level of agreement rather than divergence, while the economic and administrative aspects showed greater divergence. While statistical significance was not established in some instances, consensus on the strategies and barriers was reached based on the defined acceptance criteria that were the weighted mean (≥ 3.5) and the coefficient of variation (≤ 0.5). These criteria indicate importance of variables and the reliability evaluation consistency of expert, which is common among exploratory studies (Delphi method). Although Kendall's W did not reach statistical significance for some dimensions, this does not necessarily invalidate the Delphi outcomes. In this study, expert consensus was determined primarily using the predefined acceptance criteria (weighted mean ≥ 3.5 and coefficient of variation ≤ 0.5), while Kendall's W was used as a complementary measure to assess the degree of agreement among experts. Therefore, the non-significant Kendall's W values indicate relatively weaker concordance in some dimensions rather than the absence of consensus. Nevertheless, this should be acknowledged as a limitation of the study, suggesting that consensus in the economic and administrative dimensions should be interpreted with greater caution and may benefit from

validation using larger expert panels in future research. Overall, the findings support the reliability of the final list of sustainability strategies and barriers, while acknowledging that agreement was stronger in some dimensions than in others.

Table 23. Consensus and Stability Analysis Results Across Sustainability Dimensions

Statistical Measures	Environmental		Economic		Social		Administrative	
	Strategies	Barriers	Strategies	Barriers	Strategies	Barriers	Strategies	Barriers
Kendall's W	0.288	0.156	0.18	0.074	0.235	0.208	0.09	0.125
P-value	0.000	0.052	0.007	0.396	0.000	0.001	0.279	0.056
Chi-Square	64.55	10.944	22.692	6.243	36.264	29.053	6.289	19.268
Stability %	3.72	1.06	0.14	3.69	0.61	0.85	6.77	1.06
Stability Status	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Stable	Highly Stable

4.4 Proposed Framework

A conceptual framework was developed to support the implementation of sustainability in the Iraqi construction sector, by drawing from the Delphi study. This theoretical foundation lies under criteria for a final list of 36 strategies and 32 obstacles, which were selected following the application of acceptance criteria. The framework is presented in four dimensions: 11 strategies and 5 obstacles in the environmental dimension, 8 strategies and 7 obstacles in the economic dimension, 10 strategies and 8 obstacles in the social dimension, and 7 strategies and 12 obstacles in the administrative dimension. The policy framework gives weight to the most beneficial strategies on the one hand and overcomes the main obstacles to their implementation on the other hand. It further underscores the inter-related aspects of the environmental, economic, social and administrative aspects of the issue, and the importance of coherent institutional, technical and organizational approaches to bring about more effective and implementable sustainability goals. **Fig. 1** shows the proposed sustainability prioritization framework for the Iraqi construction sector.

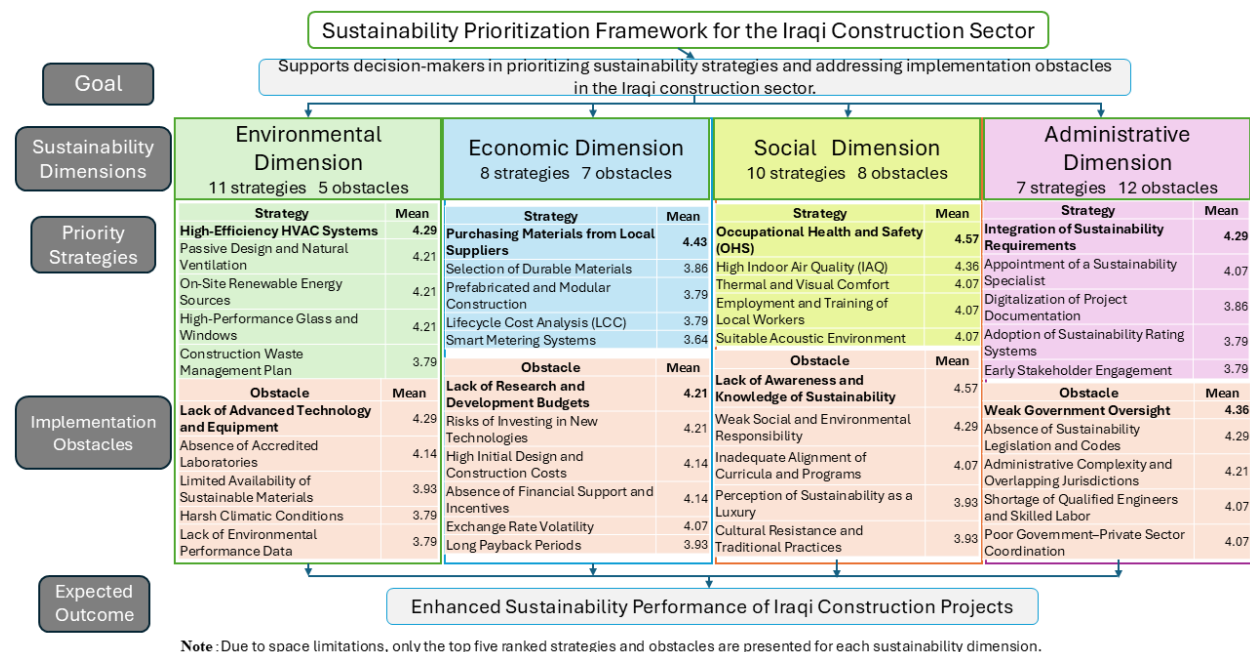


Figure 1. Sustainability prioritization framework for the Iraqi construction sector



5. CONCLUSIONS

This study demonstrates that advancing sustainable construction in the Iraqi construction sector requires an integrated approach that addresses environmental, economic, social, and administrative dimensions simultaneously. The findings indicate that sustainability implementation should extend beyond isolated environmental or technical practices to encompass resource efficiency, economic feasibility, social responsibility, and effective institutional governance. Energy efficiency, occupational health and safety, and the integration of sustainability requirements into project and contract management emerged as key strategic priorities. However, their effective implementation depends on addressing the government-related, financial, technological, and institutional barriers identified by the experts. This suggests that progress toward sustainable construction in Iraq requires coordinated policy, regulatory, financial, and capacity-building measures rather than isolated technical interventions. The consensus and stability achieved through the Delphi process support the identified priorities and provide a basis for the proposed framework, which integrates sustainability strategies and implementation barriers within the Iraqi construction context. The framework can assist policymakers, government agencies, project owners, consultants, and contractors in directing resources and improvement efforts toward priority areas and in supporting more systematic sustainability-related decision-making. The findings should nevertheless be interpreted within the scope of the study. The expert panel was limited to the Iraqi construction sector, and the proposed framework reflects expert-based prioritization rather than validation through actual project implementation. In addition, participants' professional experience was verified through self-reported information. Future research should therefore empirically validate the framework using data from construction projects, examine its applicability in other national contexts, and investigate whether complementary decision-support methods can further refine the prioritization of sustainability strategies and implementation barriers.

Credit Authorship Contribution Statement

Maysoon Abdullah Mansor: Conceptualization, methodology, investigation, data curation, formal analysis, writing original draft, and writing review and editing. Aodai A. Ismail, Younus Khalaf Mohammed, and Sarab Assim Hameed: Validation and writing review and editing. All authors have read and approved the final version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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نحو بناء مستدام في العراق: تحديد الاستراتيجيات ومعوقات التنفيذ بناءً على آراء الخبراء

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الخلاصة

يُمثل البناء المستدام في العراق تحديًا كبيرًا، على الرغم من الدور المحوري الذي يلعبه قطاع البناء في تعزيز التنمية وآثارها. تكمن المشكلة في غياب مبادئ توجيهية واضحة، ووجود عوائق تحول دون تطبيق ممارسات الاستدامة. هدفت هذه الدراسة إلى استكشاف استراتيجيات البناء المستدام في البيئة العراقية وتصنيفها، وتحديد التحديات التي تواجه تنفيذها. استخدمت الدراسة منهجية دلفي ثنائية المراحل، بمشاركة 16 متخصصًا في الجولة الأولى و14 في الجولة الثانية. وبناءً على مراجعة الأدبيات، تم تحديد 42 استراتيجية و24 عائقًا في البداية، ثم تم توسيعها لاحقًا إلى 36 عائقًا و46 استراتيجية بناءً على توصية الخبراء. تم تقييم الأهمية ودرجة الاتفاق باستخدام أساليب إحصائية، مثل المتوسطات المرجحة، ومعاملات التباين، ومعامل كندال، واختبار مربع كاي، وتحليل الثبات. أسفرت النتائج عن اعتماد 36 استراتيجية و32 عائقًا بعد استبعاد العوامل التي لم تستوفِ معايير القبول المحددة، مما يعكس استقرار جميع الأبعاد، حيث كانت معدلات الاستقرار أقل من الحد الأدنى المحدد (15%)، وهو ما يُثبت كفاية جولتي دلفي. وشملت بعض أبرز الاستراتيجيات أنظمة البناء الموفرة للطاقة، والصحة المهنية، وتخطيط السلامة، ومراعاة متطلبات الاستدامة في العقود وإدارة المشاريع. في المقابل، تمثلت أكبر التحديات في ضعف الأطر التشريعية والتنظيمية، وصعوبة الوصول إلى التقنيات والمواد المستدامة، والقيود المالية والمؤسسية. وتقدم هذه الورقة البحثية دليلًا لترتيب هذه الأولويات بهدف تشجيع تبني البناء المستدام في العراق.

الكلمات المفتاحية: البناء المستدام، إستراتيجيات الاستدامة، معوقات التنفيذ، اجماع الخبراء، طريقة دلفي.