University of Baghdad
College of Engineering
JOURNAL OF ENGINEERING

Journal of Engineering

journal homepage: www.jcoeng.edu.iq

Volume 31 Number 11 November 2025

A Proposed Framework for Green Procurement within Green Supply Chain Management in Iraqi Construction Sector

Ameer Kadhim Abdul Zahra *, Ahmed Mohammed Raoof Mahjoob

Department of Civil Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq

ABSTRACT

In recent times, environmental conservation has become a critical factor in the success of industries worldwide, particularly in the construction sector, which has a significant environmental footprint. In response, Green Supply Chain Management (GSCM) provides a strategic approach to integrating sustainability into procurement practices. This study proposes a structured framework for green procurement within GSCM, aligning sustainability principles with project management standards in accordance with ISO 10006:2017. A thorough literature review was conducted to identify main factors influencing green procurement. These factors were then refined through an open-ended questionnaire administered to industry professionals. Based on their feedback, a closed-ended questionnaire was developed and distributed to 73 experts in procurement and supply chain management. The responses were analyzed using a five-point Likert scale. The results identified the most influential factors for effective green procurement: quality control of material, certified supplier, purchasing non-toxic material, supplier audits, supplier selection, specifications for suppliers, purchasing eco-labeled material and suppliers must have ISO 14001 certification to take part in tenders. Based on these findings, a comprehensive framework was developed by linking each factor to the relevant project stakeholders and phases outlined in ISO 10006:2017. This framework aims to enhance procurement performance and promote sustainable, interoperable supply chain practices.

Keywords: Framework, Green procurement, Green supply chain management, ISO 10006:2017, Iraqi construction sector.

1. INTRODUCTION

The UN Sustainable Development Goals (SDGs) acknowledge the necessity for extensive efforts towards global sustainable transformation. Firm engagement is acknowledged as a crucial factor in influencing both public and private sectors to mobilize markets and societies for collective changes aimed at sustainability **(United Nations, 2015)**. Companies play a dual role as both participants and leaders in sustainable development **(Sachs and Sachs,**

*Corresponding author
Peer review under the responsibility of University of Baghdad.
https://doi.org/10.31026/j.eng.2025.11.11

Article received: 05/06/2025
Article revised: 06/08/2025
Article accepted: 13/08/2025
Article published: 01/11/2025

2021; Shrivastava, 2018). Supply chains are anticipated to produce the highest carbon emissions from corporate operations. Effective sustainable supply chain management is a crucial element in improving corporate and social value within the framework of the Sustainable Development Goals **(United Nations Global Compact, 2015)**.

Green procurement and supply are essential activities in developing a sustainable supply chain and are anticipated to significantly enhance long-term firm performance **(Hsu and Hu, 2008)**. Green procurement integrates environmental protection considerations into the procurement strategy to ensure that products and materials acquired meet specified environmental objectives **(Min and Galle, 2001)**.

The exploitation of resources and the swift progression of climate change have resulted in numerous catastrophic events in the past, raising significant concerns among government entities globally. The uncontrolled growth of business operations has been identified as a significant factor contributing to the degradation of resources and the environment **(Fahimnia and Jabbarzadeh, 2016)**. Procurement significantly contributes to overall carbon emissions within the supply chain, resulting in environmental disasters **(Benjaafar et al., 2013)**. Green supply denotes that companies improve their supply sustainability by collaborating and integrating with suppliers **(Paulraj, 2009)**.

Where sustainable procurement is a crucial initial step towards establishing a sustainable supply chain for any corporate organization. A strategic alliance between purchasers and their suppliers is crucial for attaining the specified environmental performance objectives **(Geffen and Rothenberg, 2000)**. Sustainable practices employed by suppliers may serve as factors for supplier selection. This may foster healthy competition among suppliers and thereby diminish carbon emissions produced by them. Highlighting the significance of supplier selection in procurement decisions.

(Ware et al., 2014) introduced a dynamic model for supplier selection, subsequently enhanced to a flexible supplier selection model that integrates both qualitative and quantitative elements. In the context of selecting suppliers when making purchasing decisions, **(Hsu et al., 2011; Kaur et al., 2016)** used in their research determinants that contribute to encouraging suppliers to reduce their carbon footprint by switching to environmentally friendly practices, which ensures remaining competitive. Part of the research discussed is based on an integral part of the purchasing process, which is the qualitative evaluation of suppliers, as the purchasing and reverse logistics processes include modeling part of the requirements for selecting suppliers and transportation companies.

In another context, green purchasing focuses on environmental considerations, particularly reducing material consumption, as well as reusing and recycling materials during the purchasing process. Companies that prioritize the environment and its preservation consider these criteria important because they aim to ensure that their products are less harmful to the environment **(Rizzi et al., 2014)**. It can also be said that these criteria are important for decision-makers who focus on environmental aspects, which may also include the impact of their personal behavior, as well as the influence of suppliers on their decisions, as well as their primary resources **(Ike et al., 2019)**.

Green procurement also plays a fundamental role in achieving environmental goals. Many organizations consider it an effective long-term strategy for reducing pollution. To improve environmental performance, understand green procurement strategies, and leverage their impact, companies can evaluate their green procurement functions **(Govindan et al., 2014)**. Organizations may also categorize suppliers based on their commitment to sustainability standards, environmentally friendly practices, and their ability to manage green operations

(Govindan et al., 2014). Public procurement activities focus on acquiring supplies with positive environmental characteristics, such as the ability to reduce waste, recycle, and optimize post-recycling reuse, and their freedom from environmentally harmful and hazardous materials **(Phawitpiriyakliti et al., 2020)**.

An international comparison of GSCM frameworks goes to show the unique contribution of the present work. In what may be viewed as an extension of the maintenance conventions mentioned above, **(Wiguna et al., 2021)** designed a framework of the Indonesian construction sector and noted six major green practices that are now appended to major stakeholders, namely green design, purchasing, transportation, warehousing, construction, and recycling. Their model was constructed applying the TOPSIS approach; in it, the priorities are those of prioritizing operational practices in order to enhance both environmental and economic performance across the project lifecycle.

Conversely, **(Balasubramanian, 2012)** came up with a hierarchical ISM-based model that pinpoints 32 obstacles to the implementation of GSCM (place in 12 criteria and are either internal or external). These were leadership gaps, absence of training, deficient IT infrastructure and limited government incentives- A company has issues with structure, to implement GSCM. The current research differs from these models because it considers an operational approach to all processes involved in a project to overcome challenges through project management guidelines incorporated in the green procurement process based on ISO 10006:2017. The proposed framework offers a more governance-oriented (and, therefore, strategic) and procurement-integrated approach linking sustainability to formal project implementation, viewing the related sustainability factors (e.g., certified suppliers, ISO 14001 requirements, eco-labeled materials) in terms of the need to address them and assign them to particular project phases and roles of stakeholders.

The purpose of this study is to develop a theoretical framework for green procurement in the context of GSCM in Iraqi construction industry by focusing on the significance of enhancing environmental practices in the procurement process to sustain a greener environment. Each of the 8 sub-factors are all linked with the project stakeholders and project organization, as can be expected within the international standard for project management, ISO 10006:2017. The model endeavors to deep green sustainability and bring it to life by umeriding green procurement standards and practices in the selected project stages. This can possibly help to minimize the environmental impacts of these processes in the construction industry and enhance resource utilization. It can also contribute for the effort of the development of more comprehensive green procurement policies in specific, and in the environmental consideration in general in the Iraqi construction industry.

2. RESEARCH METHODOLOGY

The methodology for diagnosing green supply chain management methods within the construction sector was outlined as follows:

2.1 Data Collection

The data gathering process encompassed a literature study to identify sub-factors of green procurement, along with an open-ended questionnaire to gather insights from project practitioners (experts). A closed-ended questionnaire was created, incorporating 10 sub-factors of green procurement, based on theoretical analysis and open-ended questions. **Table 1** shows the main factor as well as the secondary factors by summarizing previous studies.

Table 1. Summary of green supply chain management sub-factors from previous studies.

No.	Factors	References
	Green procurement	
1	Purchasing non-toxic material	**(Shurrab et al., 2018)**
2	Purchasing eco-labeled material	**(Zhu et al., 2005)**
3	Suppliers must have ISO 14001 certification to take part in tenders	**(Shurrab et al., 2018)**
4	Specifications for suppliers	**(Sellitto et al., 2019)**
5	Supplier selection	**(Tseng and Chiu, 2013)**
6	Supplier audits	**(Zhu et al., 2013)**
7	Evaluation of second level suppliers	**(Eltayeb and Zailani, 2014)**
8	Environmental audit for supplier's internal management	**(Zhu et al., 2008)**
9	Quality Control of Material	**(Ghobakhloo et al., 2013)**
10	Certified supplier	**(Ghobakhloo et al., 2013)**

2.2 Design of the Questionnaire

The survey comprised two sections. The initial portion requested participants to furnish demographic information. The second segment involved participants assessing the influence of 10 sub-factors utilizing a 5-point Likert scale (1 = never to 5 = always).

2.3 Dissemination of the Questionnaire

Prior to the dissemination of the closed questionnaire, the questionnaire model was introduced through interviews with a cohort of twelve experts from Baghdad, Al-Najaf, and Karbala in Iraq, each possessing a minimum of 25 years of expertise in construction and implementation projects. They conducted a review and offered straightforward remarks, revisions, and ideas. This step assesses the clarity of the questions, determining their comprehensibility and identifying potential issues in completing the closed questionnaire. Upon validating the initial phase and endorsing the finalized questionnaire model, eighty questionnaires were disseminated to a selected cohort of engineers and specialists engaged in construction and implementation projects, with extensive knowledge in this field. The questionnaire was additionally disseminated via personal interviews. Following the collection of the questionnaires, seven were excluded due to incomplete information. A total of 73 questionnaires were examined and analyzed among the closed questionnaires.

2.4 Data Analysis (Assessment of Reliability and Validity)

The design process of research equipment is significantly influenced by reliability. Where statistical analysis must validate the questionnaire's reliability prior to its administration **(Princy and Shanmugapriya, 2017)**. To evaluate the stability and equivalence of reliability tests, it is required to conduct reliability assessments to measure actual scores, which are a crucial yet insufficient component of the instrument's validity: a systematic methodology for consistent evaluation criteria.

Calculating Cronbach's Alpha (α) assesses the reliability coefficient. Where a multitude of case studies in the social sciences employ Cronbach's alpha. A reliability coefficient of 0.70 or higher is deemed adequate **(Mohammed and Jasim, 2018)**. During The questionnaire's validity can be determined using Eq. (1) **(Noaman and Rezzoqi, 2022)**:

$$v = \sqrt[2]{\alpha} \quad (1)$$

Using statistical analysis software (Microsoft Excel 2021 and IBM SPSS Version 27), the reliability and validity v of the questionnaire for main factor were assessed. For the main factor of Green Procurement, the Cronbach's Alpha (α), indicating dependability, was 0.861, demonstrating good reliability. Additionally, the validity coefficient for Green Procurement was 0.928, confirming the validity of the measurement.

3. ANALYSIS OF CLOSED QUESTIONNAIRES

Following the collection of data from qualified participants through a structured questionnaire, the findings were analyzed and interpreted systematically according to the predefined sections. Each dimension was individually assessed, presented, and validated to ensure clarity and methodological rigor.

3.1 Personal Information

Data collected from survey participants undergoes a comprehensive item-by-item analysis. The aggregated findings are subsequently structured and presented in **Table 2** to ensure clarity and facilitate interpretation.

Table 2. Respondents' personal information.

Item	Answer	No.	Percentage
Personal category	Male	61	83.56
	Female	12	16.44
	Total	**73**	**100**
Academic Degree	B.Sc.	44	60.27
	M.Sc.	18	24.66
	Ph.D.	11	15.07
	Total	**73**	**100**
Engineering Specializations	Civil	42	57.53
	Mechanical	15	20.55
	Electrical	8	10.96
	Architectural	2	2.74
	Survey	2	2.74
	Materials	2	2.74
	Communications and electronics	2	2.74
	Total	**73**	**100**
Job Sector	Public	58	79.45
	Private	15	20.55
	Total	**73**	**100**
Experience of Respondents	(5-9)	5	6.85
	(10-14)	11	15.07
	(15-19)	17	23.29
	(20-24)	15	20.55
	(25-29)	4	5.48
	30 or More	21	28.76
	Total	**73**	**100**

3.2 Evaluation of the Sub-factors

The sub-factors were examined utilizing the arithmetic mean and standard deviation with Excel 2021 and SPSS V.27. Factors or sub-factors with values surpassing the arithmetic mean of 3.4 were retained to determine the significance of the indicators, while those below this threshold were excluded to identify factors with a high acceptance rate. By segmenting the data into periods, the top two periods were selected to capture the factors with the highest acceptance rate, as the third period indicates neutrality. Values exceeding 3.4 reflect positive responses and are the most prevalent in the questionnaire. **Table 3** is the fundamental reference for selecting factors based on the arithmetic mean and segmenting the mean periods. Upon concluding all statistical studies and establishing the acceptable arithmetic mean, a final table was constructed displaying all primary and secondary elements in sequence. **Table 4** presents the final ranking of the sub-factors related to the main factor, green procurement.

Table 3. Mean frequency of sample direction.

Direction	Category
Never	1 – 1.8
Rarely	1.8 – 2.6
Sometimes	2.6 – 3.4
Often	3.4 – 4.2
Always	4.2 – 5

Table 4. Final ranking of sub-factors related to green procurement.

Main factor	No.	Sub-factor	Rank	Mean	Rating Level
Green Procurement	1-1	Quality Control of Material	1	4.288	Always
	1-2	Certified supplier	2	4.096	Often
	1-3	Purchasing non-toxic material	3	3.836	Often
	1-4	Supplier audits	4	3.836	Often
	1-5	Supplier selection	5	3.781	Often
	1-6	Specifications for suppliers	6	3.767	Often
	1-7	Purchasing eco-labeled material	7	3.658	Often
	1-8	Suppliers must have ISO 14001 certification to take part in tenders	8	3.616	Often

4. FRAMEWORK FOR GREEN PROCUREMENT SUB-FACTORS

Below, a framework for green procurement management will be developed, which will contribute significantly to green supply chain management. Each sub-factor will be linked to the project stakeholders, as well as the project phases, divided according to the ISO 10006:2017 standard. ISO 10006:2017, referred to by **(Abdullah et al., 2021)**, is titled "Quality Management: Guidelines for Quality Management in Projects" and was released in November 2017. This is the third edition of the standards series. Before this, ISO 10006:1997 and ISO 10006:2003 were in existence. This specification enhances the guidelines outlined in ISO 21500:2012 and aligns with ISO 9001:2015, as all these standards are fundamentally grounded in seven quality management principles: customer focus, leadership, employee empowerment, evidence-based decision-making, and continual improvement. It is an extensive specification applicable to small, medium, big, and extremely large projects

(Alafandi, 2018). This specification offers overarching guidelines to enhance quality management in projects, irrespective of its type, scale, scope, length, complexity, processes, and deliverables **(Krpan, 2022)**. Top management bears the primary responsibility for attaining quality objectives, motivated by a commitment to organizational excellence and stakeholder satisfaction. However, each department must also be accountable for its specific products. ISO 10006 is an international standard and specification established by the International Organization for Standardization (ISO) that directs the implementation of a quality management system in projects. This pertains to initiatives of diverse complexity, whether little or substantial, of brief or extended length, across various contexts, irrespective of the nature of the product or process involved.

5. PROPOSED FRAMEWORK FOR GREEN PROCUREMENT

The following section presents the proposed conceptual framework developed to support the effective implementation of green procurement factors within organizational or project-based contexts. This framework aims to illustrate the key components, relationships, and processes that facilitate environmentally responsible purchasing decisions.

5.1 Quality Control of Material

This section describes the relationship between the quality control of material, project parties, and the main project processes as defined by ISO 10006:2017. The relationship will be with the project parties' which involves multiple stakeholders, particularly suppliers, contractors, and consultants. The suppliers are primarily responsible for providing materials that meet specified environmental and technical standards. Their role is proactive, where they must source, produce, and deliver products that comply with green procurement criteria, such as recyclability, low emissions, or non-toxicity. It is a duty that is critical to the promotion of sustainability during the initial phases of the supply chain **(Wang et al., 2023)**. Contractors have the duty of ensuring that the materials received comply with the project standards as well as the environmental specifications. Contractors are the first responders of the on-site sustainability measures through inspections and quality control measures. Contractors in partnership with the project consultant strive to avoid the utilization of any materials that are non-project compliant and non-compliant to the regulatory standards in the course of implementation **(Zhang et al., 2023)**. The consultants supervise and review the conformity of construction materials to specifications during on-site quality inspection **(Tam et al., 2007)**.

The relationship to the project processes for this sub-factor is also closely related to many project management processes, particularly risk-related processes, procurement, and cost-related processes. In risk-related processes, poor-quality materials significantly cause structural failure, legal non-compliance, and environmental damage. Establishing strict quality controls can reduce this risk by preventing the use of unsuitable materials **(Zuo and Zhao, 2019)**. In the procurement process, it is important that materials used should meet the specifications regarding quality thus attaining a green procurement policy of a project. Supplier's certification has to be checked, material data sheets should be asked and procurement should be in accordance with green goals **(Oliveira et al., 2021)**. Considering the cost-related processes, high-quality materials are good but they will be expensive at the beginning. Nevertheless, they can save the large expenditure in future, by maintaining, reworking misleading design and die before design time. Such a tactical investment minimizes the overall lifecycle cost of a building **(Hassan et al., 2023)**.

5.2 Certified Supplier

This part discusses how certified suppliers interact with project actors and project management processes, as structured by ISO 10006:2017. The relationship will be with project parties' suppliers, owners, managers, and executives. The suppliers must obtain a recognized environmental certification to ensure they meet environmental standards **(Chiarini, 2012)**. The owners are committed to working with certified suppliers to ensure the quality of materials and minimize environmental risks **(Oliveira et al., 2021)**. The managers and executives establish policies requiring collaboration with certified suppliers as part of the organization's environmental responsibility strategy **(Ağan et al., 2016)**.
The relationship with the project processes for this sub-factor is also closely related to many project management processes, such as procurement, risk-related processes, and cost-related processes. The procurement process involves evaluating suppliers based on their environmental certifications as part of the selection and evaluation process **(Adamides and Mouzakitis, 2024)**. In Risk-related processes, using non-certified suppliers increases the legal and environmental risks of your project **(Wang et al., 2023)**, and for cost-related processes, certified suppliers can provide higher-quality materials, which may reduce maintenance costs (and future compensation) **(Yu et al., 2022)**.

5.3 Purchasing Non-Toxic Material

In line with ISO 10006:2017, this section addresses the coordination between stakeholders and project procedures in relation to the purchasing non-toxic material. The relationship with project parties for implementing this sub-factor requires cooperation from multiple parties, including suppliers, contractors, and owners. The suppliers must provide building materials certified to be free of toxic substances, such as low-volatile organic compound (VOC) paint or formaldehyde-free insulation **(Salt Hammer et al., 2023)**. The contractors will see to it that non-toxic items are used when constructing and that they can be used effectively towards a healthy condition **(Ejiofor et al., 2018)**. The owners and the end users get the immediate benefit of a healthy pollution-free indoor environment and a decreased health risk through exposure to harmful chemicals **(Nassikas et al., 2024)**.
On the other hand, the relationship with the project processes of this sub-factor has some period of overlapping with processes that make up the project management, including risk-related processes, procurement processes, and cost-related processes. In the case of risk-related processes, non-toxic material substitution lowers the health-related risks to both the employees and final users and limits or eliminates the legal liability risks to the company in case of health-related accidents **(Bodar et al., 2018)**. The procurement must identify a procurement policy that supports the use of certified and environmentally friendly materials to enhance the environmental compliance commitment of the project **(Wong et al., 2016)**. This sub-factor also applies to the processes related to costs as even though the non-toxic materials might be more expensive today, their implementation will result in the reduction of long-term costs connected with contamination and processing steps, which means their implementation will eventually result in financial savings **(Rounaghi et al., 2021)**.

5.4 Supplier Audits

This component highlights the role of supplier audits and their association with project participants and key procedural elements, according to ISO 10006:2017. The relationship with project parties implementing this factor requires cooperation from managers and

executives, and consultants' parties involved in the project managers and executives play a pivotal role in overseeing supplier compliance with established standards and in the formal approval of environmental audit results. Their involvement ensures strategic governance, reinforces accountability mechanisms, and facilitates the alignment of audit findings with broader organizational policies and sustainability goals **(Carter and Rogers, 2008)**. The consultants contribute significantly to supplier audits by providing specialized expertise that guides the audit process, assists in interpreting regulatory requirements, and supports organizations in implementing best practices to ensure thorough evaluation and compliance of suppliers with environmental and contractual standards **(Lyons, 2024)**.

While the relationship to project processes, this factor overlaps with the procurement process, where audit results are used as criteria for making procurement decisions. Suppliers that do not meet environmental standards will be excluded or required to make improvements, thereby improving the quality and sustainability of the procurement process **(Wang et al., 2023)**.

5.5 Supplier Selection

This part reviews the influence of supplier selection on project stakeholders and management processes under the framework provided by ISO 10006:2017. The relationship with project parties' owners and legal and regulatory agencies, the owners where selecting a supplier is crucial in supporting environmental sustainability within the supply chain, as this decision directly impacts the project's compliance with environmental and legislative standards. When it comes to the sustainability of projects, a more sustainable choice is to choose suppliers with an environmental certification, like ISO 14001 or those who have instituted an evident environmental management model **(Urbaniak and Ropęga, 2018)**. As agencies, legal and regulatory agents also play an important role in defining acceptance criteria because they could mandate certain legislations or certification to be met by suppliers. The suppliers should also be able to show that they are adhering to these standards both on paper and in practice. They have also suggested that the process of choosing environmentally friendly suppliers is a good process towards enhancing the environmental performance in companies and hence reducing pollution, resource consumption and waste through enhancement of the environmental competitiveness of the organizations **(Li and Zhong, 2024)**.

Although the relationship with project processes concerning this sub-factor involves in scope-related processes and communication processes. Related communication processes require the team to communicate with potential providers and establish their environmental commitment, and examine their documents of certification **(Mesfin, 2022)**. It also applies to the scope of related processes when the selection of suppliers should be in line with domestic and global regulations when it comes to the environment **(Mathiyazhagan et al., 2018)**.

5.6 Specifications for Suppliers

This section outlines how specifications for suppliers are integrated within the roles of project parties and project processes, in accordance with ISO 10006:2017. The relationship with the supplier and consultants of the project parties. The suppliers play an important role in enhancing the green procurement since they define the environmental and technical parameters to be accomplished in delivering goods or services. Such specifications make

sure that materials and processes can satisfy the project environmental aspirations and are also precautionary steps to abate emissions and waste besides abridging the hazards to health **(Foerstl et al., 2010)**. The consultants as well have a peripheral role in overseeing compliance and revising the specifications following the best practice **(Testa et al., 2023)**. Although the connection between this sub-factor and the project processes is established through the procurement process and scope-related processes, since green requirements are required to be determined at the planning level and integrated into tenders and contracting documents, it means that the environmental standards are followed even before the beginning and because of final delivery **(Dua, 2021)**.

5.7 Purchasing Eco-Labeled Material

Based on ISO 10006:2017, this subsection examines the relationship between purchasing eco-labeled material, project parties, and process execution. The suppliers must provide products with approved environmental ratings, while the contractors are obliged to use these products in implementation to achieve the required sustainability standards **(Khan et al., 2022)**. The relationship to project processes for this sub-factor is related to the procurement process and risk-related processes. For the procurement process, using environmentally friendly materials reduces environmental impact. It ensures the organization procures materials certified by eco-labels (e.g., Energy Star, FSC, or EPEAT), promoting sustainability and compliance with green procurement standards **(Smith, 2023)**. The risk process is associated with environmental compliance and unintended negative impacts on health or the environment and simplifies legal and regulatory procedures **(Gurtoo and Antony, 2007)**.

5.8 Suppliers Must Have ISO 14001 Certification to Take Part in Tenders

This part focuses on suppliers must have ISO 14001 certification to take part in tenders and its influence on stakeholders and project management activities, following ISO 10006:2017 principles. The relationship with project parties from the perspective of the parties involved, the major stakeholder in relation to this sub-factor is the concerned suppliers and contractors. In demonstrating compliance, the suppliers must be ISO 14001 certified. It is possible that the existence of ISO 14001 certification as a supplier qualification requirement also leads to the improved environmental performance of construction projects and the stakeholders finding greater confidence in the quality of products and services **(Zuo et al., 2023)**. Ensuring that suppliers can do so is the responsibility of contractors **(Makkinga et al., 2018)**. This sub-factor concerns processes of procurement and risks. Turning to procurement, the ISO 14001 certification can be used to enhance transparency and eliminate environmental mistakes so that the evaluation and review would be more effective **(Camilleri, 2022)**. The processes of risk can also help the projects to dodge inefficient suppliers in environmental performance and lessen legal responsibilities in case of an environmental law violation **(Dobler et al., 2014)**.

6. RESULTS AND DISCUSSION

This study employed a closed-ended questionnaire using a five-point Likert scale, which was completed by 73 experts in procurement and supply chain management. The survey yielded valuable insights into current industry practices, priorities, and perceptions regarding the adoption of sustainable procurement within the construction sector.

The results identified several key sub-factors that significantly contribute to enhancing green procurement practices. These include quality control of material, certified supplier, purchasing non-toxic material, supplier audits, supplier selection, specifications for suppliers, purchasing eco-labeled material, and suppliers must have ISO 14001 certification to take part in tenders.

Among these, quality control of material received the highest rating, reflecting its critical role in ensuring the use of environmentally compliant materials across different project stages. This factor's strong association with suppliers, contractors, and consultants—as well as with key project management processes like risk, procurement, and cost control—is clearly illustrated in **Fig. 1**.

Certified supplier and purchasing non-toxic material were also highly rated, indicating the growing industry commitment to environmental compliance and internationally recognized sustainability standards. Their interactions with multiple stakeholders and core project processes are visualized in **Fig. 2** and **Fig. 3**, respectively. These practices help mitigate legal and environmental risks and support long-term cost reduction through improved material selection

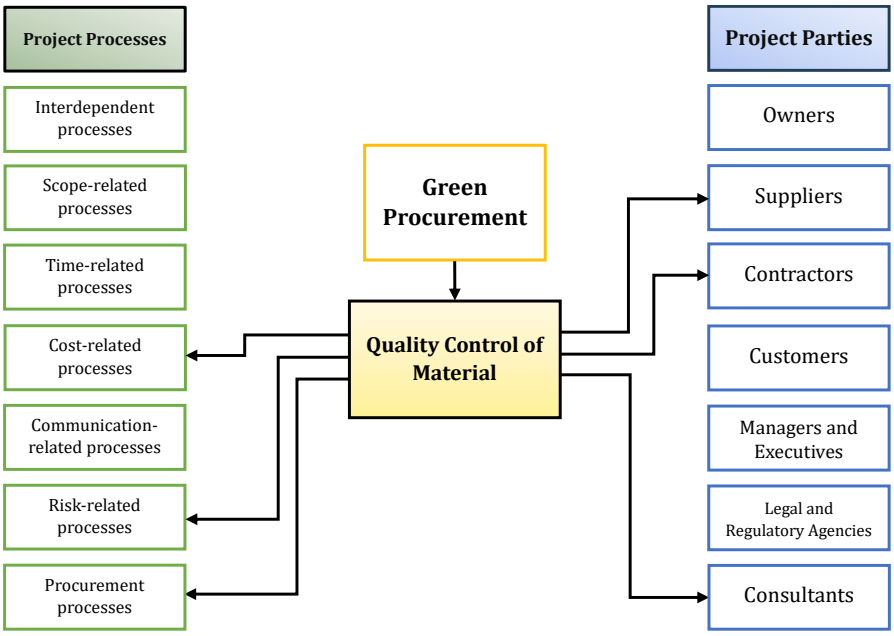

Figure 1. The proposed framework for quality control of material with the project parties and processes.

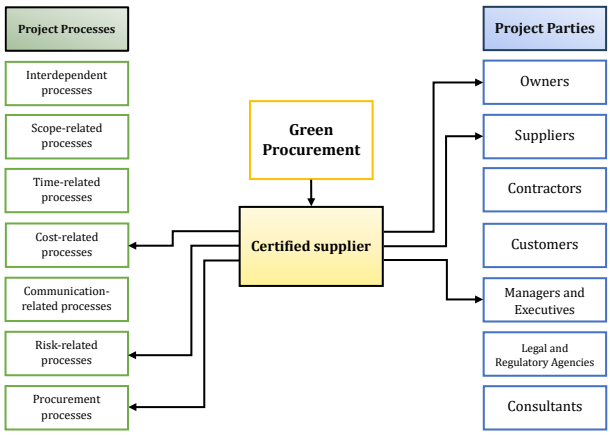

Figure 2. The proposed framework for certified supplier with the project parties and processes.

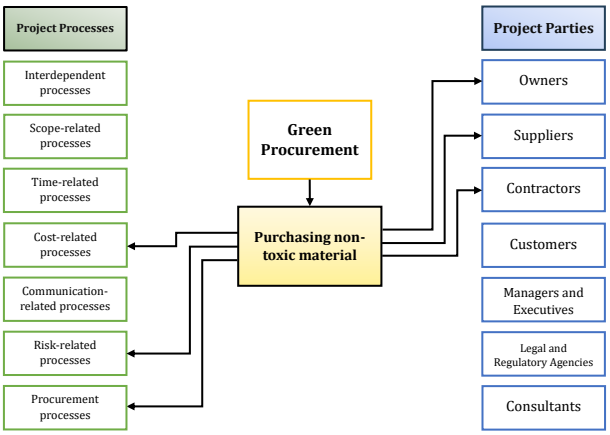

Figure 3. The proposed framework for purchasing non-toxic material with the project parties and processes.

Furthermore, supplier audits and supplier selection, depicted in **Fig. 4** and **Fig. 5**, play a vital role in evaluating and ensuring supplier compliance throughout the project lifecycle. While audits contribute to monitoring and continuous improvement during implementation, proper supplier selection is foundational during planning and procurement phases. Legal and regulatory agencies also influence this process by setting compliance benchmarks and acceptance criteria.

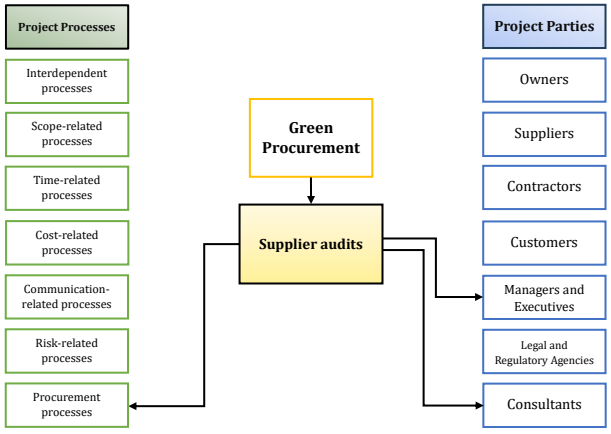

Figure 4. The proposed framework for supplier audits with the project parties and processes.

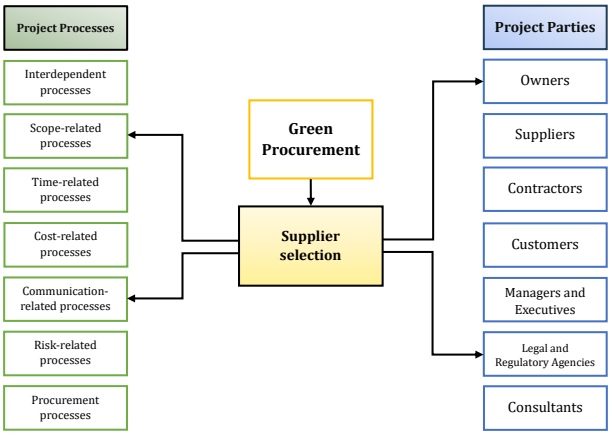

Figure 5. The proposed framework for supplier selection with the project parties and processes.

The specifications for suppliers in **Fig. 6** demonstrate how environmental requirements must be clearly defined from the early project stages and embedded into tender documents. This ensures that sustainability standards are met from procurement through to final delivery, supporting both environmental and health objectives.

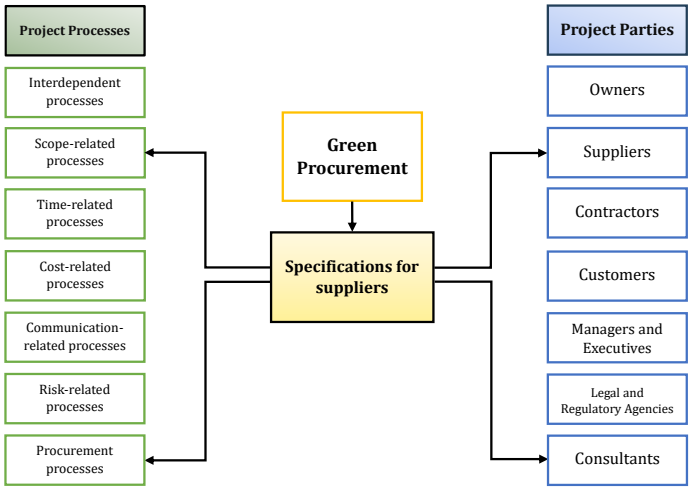

Figure 6. The proposed framework of the specifications for suppliers with the project parties and processes.

Additional emphasis is placed on purchasing eco-labeled material as on **Fig. 7** and suppliers must have ISO 14001 certification to take part in tenders as on **Fig. 8**. These sub-factors serve as effective tools to promote environmentally responsible procurement by minimizing environmental impacts, reducing legal risks, and enhancing trust in supplier performance.

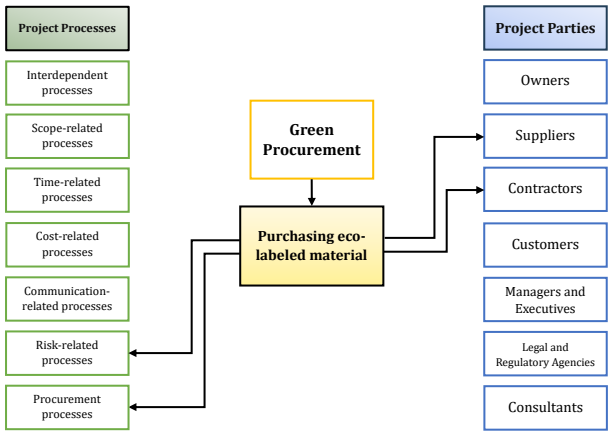

Figure 7. The proposed framework for purchasing eco-labeled material with the project parties and processes.

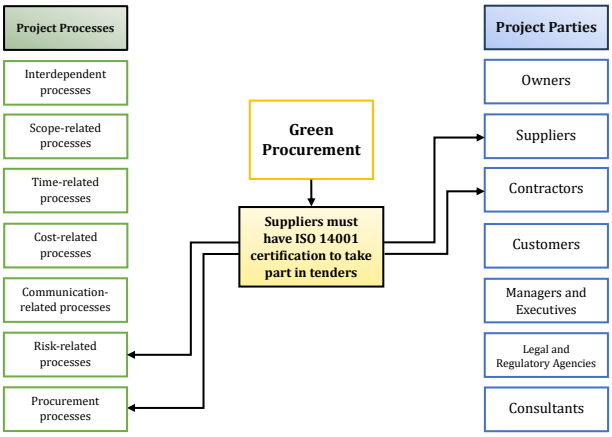

Figure 8. The proposed framework for suppliers must have ISO 14001 certification to take part in tenders with the project parties and processes.

In summary, the proposed conceptual framework as illustrated across **Figs. 1–8** captures the dynamic interactions between these sub-factors, project stakeholders, and project management processes, as aligned with ISO 10006:2017. The integrated approach ensures that environmental objectives are not merely theoretical but are embedded in measurable actions throughout the construction project lifecycle. This contributes to a more sustainable supply chain and strengthens the alignment between environmental performance and project success.

7. CONCLUSIONS

The study concluded that GSCM with green procurement element not only adds to the fulfillment of environmental regulatory requirements but also promotes efficiency and sustainability at project level. The proposed approach shows how to use the most influential environmental issues and relate them with project stakeholders and phases, so that to be able to apply in practice environmental considerations in projects. The findings reveal that a strategy including quality control, using certified suppliers and environmental certification lead to significant environmental performance improvements into the procurement process. The paper further emphasizes the need to integrate project management and green procurement by way of standard of reference (e.g. ISO 10006:2017). It is suggested that this model be applied in and tested by multiple business activities and environments with respect to future real-world case studies.

Acknowledgements

The authors would like to thank the University of Baghdad, College of Engineering, for their valuable support and the facilities provided during this research.

Credit Authorship Contribution Statement

Ameer Kadhim Abdul Zahra: Conceptualization, Methodology, Data curation, Writing – original draft. Ahmed Mohammed Raoof Mahjoob: Supervision, Validation, Writing – review & editing.

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.

REFERENCES

Abdullah, A.A., Abdul-Samad, Z., Abul-Rahman, H., and Salleh, H., 2021. Project management methods, guides and standards: A critical overview. *Journal of Project Management Practice (JPMP)*, 1(1), pp. 35–51.

Adamides, E.D., and Mouzakitis, Y., 2024. Green sourcing: Supplier assessment and selection practices across industries. *Logistics*, 8(4), P. 105. https://doi.org/10.3390/logistics8040105.

Ağan, Y., Kuzey, C., Acar, M.F., and Açıkgöz, A., 2016. The relationships between corporate social responsibility, environmental supplier development, and firm performance. *Journal of Cleaner Production*, 112, pp. 1872–1881. https://doi.org/10.1016/j.jclepro.2015.06.004.

Alafandi, A.T.A., 2018. The availability of project management quality system requirements (ISO 10006:2017): A case study in the building engineering company for contracting in Mosul. *Tanmiyat Al-Rafidain*, pp. 201–221.

Balasubramanian, S., 2012. A hierarchical framework of barriers to green supply chain management in the construction sector. *Journal of Sustainable Development*, 5(10), pp. 15-27. https://doi.org/10.5539/jsd.v5n10p15

Benjaafar, S., Li, Y., and Daskin, M., 2013. Carbon footprint and the management of supply chains: Insights from simple models. *IEEE Transactions on Automation Science and Engineering*, 10(1), pp. 99–116. https://doi.org/10.1109/TASE.2012.2204044.

Bodar, C., Spijker, J., Lijzen, J., Waaijers-van der Loop, S., Luit, R., Heugens, E., and Traas, T., 2018. Risk management of hazardous substances in a circular economy. *Journal of Environmental Management*, 212, pp. 108–114. https://doi.org/10.1016/j.jenvman.2018.02.014.

Camilleri, M.A., 2022. The rationale for ISO 14001 certification: A systematic review and a cost–benefit analysis. *Corporate Social Responsibility and Environmental Management*, 29(4), pp. 1067–1083. https://doi.org/10.1002/csr.2254.

Carter, C.R., and Rogers, D.S., 2008. A framework of sustainable supply chain management. *International Journal of Physical Distribution & Logistics Management*, 38(5), pp. 360–387. https://doi.org/10.1108/09600030810882816.

Chiarini, A., 2012. Designing an environmental sustainable supply chain through ISO 14001 standard. *Management of Environmental Quality: An International Journal*, 24(1), pp. 16–33. https://doi.org/10.1108/14777831311291141.

De Oliveira, U.R., Neto, L.A., Abreu, P.A.F., and Fernandes, V.A., 2021. Risk management applied to the reverse logistics of solid waste. *Journal of Cleaner Production*, 296, P. 126517. https://doi.org/10.1016/j.jclepro.2021.126517.

Dobler, M., Lajili, K., and Zéghal, D., 2014. Environmental performance, environmental risk and risk management. *Business Strategy and the Environment*, 23(1), pp. 1–17. https://doi.org/10.1002/bse.1763.

Dua, P., 2021. *Risks & Deterrents in Construction Projects: For Customers, Contractors, Suppliers & Consultan*. Notion Press.

Ejiofor, N., Uchechi, A.A., and Ndidi, I., 2018. Impact of sustainable construction on environmental and health risk in Nigerian construction industry. *Journal of Civil, Construction and Environmental Engineering (JCCEE)*, 3(4), pp. 99–105.

Eltayeb, T.K., and Zailani, S., 2014. Going green through green supply chain initiatives toward environmental sustainability. *Operations and Supply Chain Management: An International Journal*, 2, pp. 93–110. https://doi.org/10.31387/oscm040019.

Fahimnia, B., and Jabbarzadeh, A., 2016. Marrying supply chain sustainability and resilience: A match made in heaven. *Transportation Research Part E: Logistics and Transportation Review*, 91, pp. 306–324. https://doi.org/10.1016/j.tre.2016.02.007.

Foerstl, K., Reuter, C., Hartmann, E., and Blome, C., 2010. Managing supplier sustainability risks in a dynamically changing environment—Sustainable supplier management in the chemical industry. *Journal of Purchasing and Supply Management*, 16(2), pp. 118–130. https://doi.org/10.1016/j.pursup.2010.03.011.

Geffen, C., and Rothenberg, S., 2000. Suppliers and environmental innovation. *International Journal of Operations and Production Management*, 20(2), pp. 166–186. https://doi.org/10.1108/01443570010304242.

Ghobakhloo, M., Tang, S.H., Zulkifli, N., and Ariffin, M.K.A., 2013. an integrated framework of green supply chain management implementation. *International Journal of Innovation, Management and Technology*, 4(1), pp. 1–6. https://www.ijimt.org/show-41-647-1.html.

Govindan, K., Jafarian, A., Khodaverdi, R., and Devika, K., 2014. Two-echelon multiple-vehicle location-routing problem with time windows for optimization of sustainable supply chain network of perishable food. *International Journal of Production Economics*, 152, pp. 9–28. https://doi.org/10.1016/j.ijpe.2013.12.028.

Gurtoo, A., and Antony, S.J., 2007. Environmental regulations: indirect and unintended consequences on economy and business. *Management of Environmental Quality: An International Journal*, 18(6), pp. 626–642. https://doi.org/10.1108/14777830710826762.

Hassan, A., Ali, M., and Zhang, Y., 2023. Toxicity reduction through material selection in green buildings: An empirical assessment. *Sustainable Cities and Society*, 91, P. 104524. https://doi.org/10.1016/j.scs.2023.104524.

Hsu, C.W., and Hu, A.H., 2008. Green supply chain management in the electronic industry. *International Journal of Environmental Science & Technology*, 5(2), pp. 205–216. https://doi.org/10.1007/BF03326014.

Hsu, C.W., Chen, S.H., and Chiou, C.Y., 2011. A model for carbon management of supplier selection in green supply chain management. *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, pp. 1247–1250. Singapore. https://doi.org/10.1109/IEEM.2011.6118141.

Ike, M., Donovan, J.D., Topple, C., and Masli, E.K., 2019. A holistic perspective on corporate sustainability from a management viewpoint: evidence from Japanese manufacturing multinational enterprises. *Journal of Cleaner Production*, 216, pp. 139–151. https://doi.org/10.1016/j.jclepro.2019.01.151.

Kaur, H., Singh, S.P., and Glardon, R., 2016. An integer linear program for integrated supplier selection: A sustainable flexible framework. *Global Journal of Flexible Systems Management*, 17(2), pp. 113–134. https://doi.org/10.1007/s40171-015-0105-1.

Khan, S., El-Sayed, A., and Zhao, Y., 2022. The role of eco-labels in sustainable material selection: An empirical analysis. *Sustainable Materials and Technologies*, 32, P. e00428. https://doi.org/10.1016/j.susmat.2022.e00428.

Krpan, K., Pupavac, D., and Maršanić, R., 2022. A framework for the selection of projects at the county level in Croatia. *Hrvatska I Komparativna Javna Uprava: Časopis Za Teoriju I Praksu Javne Uprave*, 21(2), pp. 355–377.

Li, J., and Zhong, D., 2024. Comparing the impact of green supplier selection and integration on environmental performance: An analysis of the moderating role of government support. *Sustainability*, 16(16), P. 7228. https://doi.org/10.3390/su16167228.

Lyons, L.H., 2024. *Project Management Plan for the Construction of the LA CLERY SMART WELLNESS CENTER in Saint Lucia*. PhD thesis, Universidad Para La Cooperacion Internacional.

Makkinga, R., de Graaf, R., and Voordijk, H., 2018. Successful verification of subcontracted work in the construction industry. *Systems Engineering*, 21(2), pp. 131–140. https://doi.org/10.1002/sys.21432.

Mathiyazhagan, K., Sudhakar, S., and Bhalotia, A., 2018. Modeling the criteria for selection of suppliers towards green aspect: A case in Indian automobile industry. *Opsearch*, 55, pp. 65–84. https://doi.org/10.1007/s12597-017-0308-7.

Mesfin, S., 2022. *Evaluation of the Practice and Implementation of ISO 9001 Quality Management System: A Case Study of ASER Construction Company and RAMA Construction Company*. PhD Thesis, Saint Mary's University.

Min, H., and Galle, W.P., 2001. Green purchasing practices of US firms. *International Journal of Operations & Production Management*, 21(9), pp. 1222–1238. https://doi.org/10.1108/EUM0000000005923.

Mohammed, S.R., and Jasim, A.J., 2018. Examining the values and principles of agile construction management in Iraqi construction projects. *Journal of Engineering*, 24(7), pp. 114–133. https://doi.org/10.31026/j.eng.2018.07.08.

Nassikas, N.J., McCormack, M.C., Ewart, G., Balmes, J.R., Bond, T.C., Brigham, E., and Kipen, H.M., 2024. Indoor air sources of outdoor air pollution: Health consequences, policy, and recommendations: an official American Thoracic Society workshop report. *Annals of the American Thoracic Society*, 21(3), pp. 365–376. https://doi.org/10.1513/AnnalsATS.202306-531ST.

Paulraj, A., 2009. Environmental motivations: a classification scheme and its impact on environmental strategies and practices. *Business Strategy and the Environment*, 18(7), pp. 453–468. https://doi.org/10.1002/bse.612.

Phawitpiriyakliti, C., Keawkunti, B., Saisama, C., and Sangma, W., 2020. Towards environmental sustainability: A case study of green supply chain management practice. *Journal of Security and Sustainability Issues*, 9(3), pp. 747–763. https://doi.org/10.9770/jssi.2020.9.3(2).

Princy, J.D., and Shanmugapriya, S., 2017. A probabilistic fuzzy logic approach to identify productivity factors in Indian construction projects. *Journal of Construction Engineering and Project Management*, 7(3), pp. 39–55.

Rizzi, F., Frey, M., Testa, F., and Appolloni, A., 2014. Environmental value chain in green SME networks: The threat of the Abilene paradox. *Journal of Cleaner Production*, 85, pp. 265–275. https://doi.org/10.1016/j.jclepro.2014.09.001.

Rounaghi, M., Jarrar, H., and Dana, L.P., 2021. Implementation of strategic cost management in manufacturing companies: overcoming costs stickiness and increasing corporate sustainability. *Future Business Journal*, 7, pp. 1–8. https://doi.org/10.1186/s43093-021-00079-4.

Sachs, J.D., and Sachs, L.E., 2021. Business Alignment for the "Decade of Action". *Journal of International Business Policy*, 4(1), pp. 22–27. https://doi.org/10.1057/s42214-020-00090-6.

Salt hammer, T., Gu, J., Gunschera, J., and Schieweck, A., 2023. Release of chemical compounds and particulate matter. In *Springer Handbook of Wood Science and Technology*, pp. 1949–1974. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-81315-4_54.

Sellitto, M.A., Hermann, F.F., Blezs, A.E., and Barbosa-Póvoa, A.P., 2019. Describing and organizing green practices in the context of Green Supply Chain Management: Case studies. *Resources, Conservation and Recycling*, 145, pp. 1–10. https://doi.org/10.1016/j.resconrec.2019.02.013.

Shrivastava, P., 2018. Business not-as-usual to achieve SDGs under climate change. In *CSR and Climate Change Implications for Multinational Firms*, pp. 21–36. Northampton, MA: Edward Elgar Publishing.

Shurrab, J., Hussain, M., and Khan, M., 2018. Green and sustainable practices in the construction industry: A confirmatory factor analysis approach. *Engineering, Construction and Architectural Management*, 26(6), pp. 1063–1086. https://doi.org/10.1108/ECAM-02-2018-0056.

Smith, A., 2023. Green procurement practices for eco-friendly warehousing. *ResearchGate*. https://www.researchgate.net/publication/380573849.

Tam, V.W., Tam, C.M., Zeng, S.X., and Ng, W.C., 2007. Towards adoption of prefabrication in construction. *Building and Environment*, 42(10), pp. 3642–3654. https://doi.org/10.1016/j.buildenv.2006.10.003.

Testa, F., Iraldo, F., and Frey, M., 2023. Mandatory green public procurement: assessing the impact of supply specifications on environmental performance in the construction sector. *Journal of Cleaner Production*, 412, P. 137360. https://doi.org/10.1016/j.jclepro.2023.137360.

Tseng, M.L., and Chiu, A.S., 2013. Evaluating firm's green supply chain management in linguistic preferences. *Journal of Cleaner Production*, 40, pp. 22–31. https://doi.org/10.1016/j.jclepro.2010.08.007.

United Nations Global Compact, 2015. *Supply Chain Sustainability: A Practical Guide for Continuous Improvement*, 2nd ed. https://www.unglobalcompact.org/library/205.

United Nations, 2015. *Transforming our World: The 2030 Agenda for Sustainable Development*. New York, NY: United Nations. https://sdgs.un.org/2030agenda.

Urbaniak, M., and Ropęga, J., 2018. The Role of Quality and Environmental Management Systems in the Evaluation of Suppliers. *Business Logistics in Modern Management*.

Wang, L., Zhang, Y., and Chen, H., 2023. Evaluating suppliers using integrated sustainability metrics: A decision-making model. *Journal of Cleaner Production*, 412, P. 137481. https://doi.org/10.1016/j.jclepro.2023.137481.

Ware, N.R., Singh, S.P., and Banwet, D.K., 2014. A mixed-integer non-linear program to model dynamic supplier selection problem. *Expert Systems with Applications*, 41, pp. 671–678. https://doi.org/10.1016/j.eswa.2013.07.089.

Wiguna, I.P.A., Rachmawati, F., Rohman, M.A., and Setyaning, L.B.T., 2021. A framework for green supply chain management in construction sector: A case study in Indonesia. *Journal of Industrial Engineering and Management*, 14(4), pp. 788-807. https://doi.org/10.3926/jiem.3465

Wong, J.K.W., San Chan, J.K., and Wadu, M.J., 2016. Facilitating effective green procurement in construction projects: An empirical study of the enablers. *Journal of Cleaner Production*, 135, pp. 859–871. https://doi.org/10.1016/j.jclepro.2016.07.001.

Yu, W., Zhang, X., and Zheng, Y., 2022. Environmental criteria in supplier selection. *Journal of Environmental Management*, 307, P. 114504. https://doi.org/10.1016/j.jenvman.2022.114504.

Zhang, Y., Li, X., and Chen, H., 2023. Energy-efficient HVAC systems in sustainable buildings: Performance, cost savings, and implementation strategies. *Energy and Buildings*, 288, 113082. https://doi.org/10.1016/j.enbuild.2023.113082.

Zhu, Q., Sarkis, J., and Geng, Y., 2005. Green supply chain management in China: pressures, practices and performance. *International Journal of Operations and Production Management*, 25(5), pp. 449–468. https://doi.org/10.1108/01443570510593148.

Zhu, Q., Sarkis, J., and Lai, K., 2008. Confirmation of a measurement model for green supply chain management practices implementation. *International Journal of Production Economics*, 111(2), pp. 261–273. https://doi.org/10.1016/j.ijpe.2006.11.029.

Zhu, Q., Sarkis, J., and Lai, K.H., 2013. Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices. *Journal of Purchasing and Supply Management*, 19, pp. 106–117. https://doi.org/10.1016/j.pursup.2012.12.001.

Zuo, J., and Zhao, Z.Y., 2014. Green building research–current status and future agenda: A review. *Renewable and Sustainable Energy Reviews*, 30, pp. 271–281. https://doi.org/10.1016/j.rser.2013.10.021.

Zuo, J., Zhao, Z., and Wu, G., 2023. Driving environmental performance in construction projects through ISO 14001-certified suppliers. *Journal of Environmental Management*, 335, P. 117637. https://doi.org/10.1016/j.jenvman.2023.117637.

إطار عمل مقترح للمشتريات الخضراء ضمن إدارة سلسلة التوريد الخضراء في قطاع البناء العراقي

امير كاظم عبد الزهرة*، احمد محمد رؤوف محجوب

قسم الهندسة المدنية، كلية الهندسة، جامعة بغداد، بغداد، العراق

الخلاصة

في الآونة الأخيرة، أصبح الحفاظ على البيئة عاملاً حاسماً في نجاح الصناعات في جميع أنحاء العالم، وخاصة في قطاع البناء، الذي له بصمة بيئية كبيرة. واستجابة لذلك، توفر إدارة سلسلة التوريد الخضراء (GSCM) نهجًا استراتيجيًا لدمج الاستدامة في ممارسات الشراء. تقترح هذه الدراسة إطارًا منظمًا للمشتريات الخضراء داخل GSCM، مع مواءمة مبادئ الاستدامة مع معايير إدارة المشاريع وفقًا لمعيار ISO 10006:2017. وقد أجريت مراجعة شاملة للأدبيات لتحديد العوامل الرئيسية التي تؤثر على المشتريات الخضراء. ثم تم تحسين هذه العوامل من خلال استبيان مفتوح تم إجراؤه على متخصصي الصناعة. وبناءً على ملاحظاتهم، تم تطوير استبيان مغلق وتم توزيعه على 73 خبيرًا في المشتريات وإدارة سلسلة التوريد. وتم تحليل الردود باستخدام مقياس ليكرت من خمس نقاط. حددت النتائج العوامل الأكثر تأثيرًا على فعالية المشتريات الخضراء: مراقبة جودة المواد، والمورد المعتمد، وشراء المواد غير السامة، وعمليات تدقيق الموردين، واختيار الموردين، ومواصفات الموردين، وشراء المواد ذات العلامات البيئية، ويجب أن يكون لدى الموردين شهادة ISO 14001 للمشاركة في العطاءات. بناءً على هذه النتائج، وُضع إطار عمل شامل يربط كل عامل بأصحاب المصلحة المعنيين بالمشروع ومراحل المشروع المحددة في معيار ISO 10006:2017. يهدف هذا الإطار إلى تحسين أداء المشتريات وتعزيز ممارسات سلسلة التوريد المستدامة والمتوافقة.

الكلمات المفتاحية: إطار عمل، الشراء الأخضر، إدارة سلسلة التوريد الخضراء، ISO 10006:2017، قطاع البناء العراقي.