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Exploring The Nexus of Quadruple Helix Model: Driving Green Procurement in Construction Sector

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ABSTRACT

Green procurement procures products, services, and works to minimise the negative impacts throughout their life cycle. It is a concept introduced as a way forward towards a greener approach that aligns with Agenda 21 towards sustainable development. The 12th Malaysia Plan emphasised the Malaysian government's strategic commitment to integrate environmental considerations into its procurement processes. This shows Malaysia's commitment towards sustainable, greener development and promoting environmentally responsible practices in the construction sector. However, there are several challenges faced by the industry in green procurement (GP) implementation, such as a lack of engagement, commitment, low awareness, and knowledge among the construction stakeholders. Effective stakeholder engagement is essential to overcome these challenges and achieve successful green procurement implementation. There are limited frameworks for stakeholder engagement, especially to comprehensively integrate the diverse perspectives and roles of all relevant stakeholders, particularly in the context of complex construction projects. This review paper explores the potential of Quadruple Helix Model integration of construction stakeholders as a framework for driving green procurement implementation in construction projects. This study employs an integrative literature review synthesising existing research and findings, providing a comprehensive framework for understanding different levels of stakeholder collaboration. It also focuses on the important role of the main actors in construction, namely the government, construction industry, academia, and civil society in green procurement implementation. The findings highlight the importance of collaborative approaches among construction stakeholders and their interrelationships in facilitating effective green procurement practices through policy enforcement, regulatory framework, compliance, research and development, awareness, and knowledge among stakeholders. The Quadruple Helix Model aligns with sustainable development and serves as a basis framework to unite diverse stakeholders in shaping a greener and more sustainable future for construction projects.

1. Introduction

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The construction industry plays a vital role in developing infrastructure and physical facilities for people, and these activities contribute to significant environmental impacts. Transitioning to sustainable practices in the construction industry is now essential due to the rapid environmental changes [1]. The concerning impacts on the environment in the construction industry have made people more conscious of the importance of sustainable construction practices. Construction activities involve various phases and diversified construction stakeholders.

Procurement delivery is crucial for construction projects to ensure adherence to the contract. The pre-construction stage saw the making of procurement decisions, and Witek and Kuźniar [2] noted that environmental considerations had become an important issue in the industry, especially in purchasing. Greening procurement delivery is particularly important in construction projects. Many strategies have been introduced to minimise environmental impacts, and one of them is the introduction of green procurement (GP). In the 12th Malaysia Plan (2021-2025), the importance of promoting green growth for sustainability and resilience has been addressed by the Malaysian government, highlighting the need to improve the adoption mechanisms for green practices. Moreover, short-term action plans and guidelines on government green procurement (GGP) will be introduced to encourage the implementation of green practices in the construction sector. However, there are still many challenges faced by the industry, especially the construction stakeholder's engagement in green procurement implementation.

Therefore, it is important to review the nexus of Quadruple Helix Model collaboration for green procurement. This can be used as a baseline for collaboration among construction stakeholders in green procurement implementation. The Quadruple Helix offers a comprehensive understanding of the various roles played by construction stakeholders at different levels. This understanding is crucial to bolster and scale green procurement to its potential in the construction industry.

2. Quadruple Helix Model

Innovation studies are filled with new concepts aimed at understanding the changing aspects of modern society. Cai *et al*., [3] highlighted that innovation studies are filled with fresh concepts that seek to capture the characteristics of modern society. Two widely recognised conceptual frameworks in this field are the Triple Helix and Quadruple Helix models, which have been extensively applied in empirical research. The Triple Helix Model was originally proposed by Etzkowitz *et al*., [4] to explain the nexus between the government, academia, and industry in enhancing entrepreneurship, innovation, and economic growth in a knowledge-based economy. After the development of the Triple Helix, the Quadruple Helix model was introduced, incorporating public or civil society as the fourth helix [5]. This model quickly gained popularity in innovation studies. The relevance of the Quadruple Helix model extends beyond innovation studies and can be effectively applied to address complex challenges such as green procurement in construction.

2. Green Procurement in Construction

Green procurement (GP) refers to "sourcing of products and services that mitigates the potential threat to the environment and human health" [6]. Government Green Procurement (GGP) has been defined as the "procurement of supplies, services, and works by the government that takes into account environmental criteria to conserve and minimise the impact on the environment, accelerate the national economy, and promote sustainable development" [7]. For construction, the green procurement for works was established, which encompasses the minimisation of the environmental impacts of construction works in phases of the lifecycle and other physical infrastructure [8]. Green

procurement is still in the infancy level in Malaysia, and the current process suffers from fragmented efforts and insufficient integration of green practices into green procurement strategies [9]. There are a few challenges in green procurement implementation that need to be addressed to ensure that green procurement can be successfully implemented.

2.1 Challenges in Green Procurement

The construction sector involves diverse stakeholders in its activities, and the success of green procurement implementation in construction projects is dependent on commitment and stakeholder engagement. Table 2 outlines the challenges related to green procurement that need to be addressed:

Table 2
Green procurement challenges

Challenges	Authors
Stakeholder pressure	[10]
Organisational learning	
Effective communication	
Organisational structures	[11]
Knowledge-driven factors	
Attitudinal issues	
Stakeholder fatigue	
Information sharing processes	
Lack of knowledge	[12]
Lack of knowledge and awareness of GP	[13]
Low commitment	
Insufficient policies enforcement	
Limited standard green procurement guidelines	[14]

To overcome these challenges and ensure that green procurement can be implemented effectively and successfully, it is crucial to investigate the importance of collaboration among stakeholders and the interrelationships among these main actors. Thus, further exploration of the quadruple helix collaboration can facilitate the green procurement implementation in construction projects. This study explores how the role of the Quadruple model, which incorporates academia, industry, government, and civil society, can effectively relate to green procurement in construction by highlighting how each of these four key actors contributes to the development, implementation, and promotion of green practices.

3. Methodology

This study uses an integrative literature review methodology to systematically collect, analyse, and synthesise findings from diverse research articles and journals. This approach is suitable for addressing complex topics such as Quadruple Helix Collaboration and green procurement in the construction sector, as well as allowing the integration of empirical and theoretical insights. The literature search strategy conducted for this study is as follows:

Table 1
Integrative literature review strategy

Items	Description
Database search	• Scopus, Web of Science, and Google Scholar
Search Terms and Keywords	• Quadruple Helix Collaboration, Green Procurement, Construction Sector, Sustainability, Stakeholder engagement, and sustainable construction
Boolean operators	• AND, OR, NOT
Inclusion criteria	• Peer-reviewed articles, reports, and conference papers published between 2012-2023 • Written in English • Focused on the construction sector or green procurement
Exclusion criteria	• Studies that did not address the construction sector or green procurement • Not available in full text • Other languages than English

The selection process involves screening the titles and abstracts of all identified articles that are relevant to the research questions. The extracted data includes information on the role of Quadruple Helix Collaboration, which involves the government, construction stakeholders, academicians, and civil society; green procurement practices; stakeholders' involvement; and outcomes in the construction sector.

4. Results and Discussion

4.1 Quadruple Helix Model for Green Procurement Implementation

The Quadruple Helix involves the interrelationships between the government, industry, academia, and civil society. The roles of each main actor in the green procurement implementation are further discussed.

The government's involvement in policies, initiatives, and incentives can help promote and empower construction stakeholders to implement green procurement in construction projects [15]. Therefore, the government is responsible for developing and implementing policies and regulations that promote green procurement practices. It is crucial for the government to set the environmental standards and enforce compliance for green procurement practices. Regulations through regulatory frameworks are also important for the government to provide to ensure that construction projects adhere to the environmental laws and standards guidelines, thereby reducing the construction sector's ecological footprint [16].

Based on the current situation in Malaysia and the 12th Malaysia Plan (2021-2025), the government has emphasised the enhancement of green growth for sustainability and resilience. The focus is on improving the mechanisms for implementing green practices. A short-term action plan and guidelines for GGP will be introduced to promote green practices in the construction sector [17]. Moreover, the National Construction Policy 2030 emphasises sustainable development throughout the life cycle of the construction sector, and one strategy is to implement green procurement.

Table 3
Government policies and the green initiatives

Government Policy	Focus Area
9th Malaysia Plan (2006-2010)	To improve the standard and sustainability of quality of life.
National Green Technology Policy (NGTP) (2009)	Offers environmentally friendly and green products or services.
10th Malaysia Plan (2011-2015)	Building an environment that enhances the quality of life. Intensifying efforts to reduce GHG emissions from the manufacturing sector by promoting efficient use of energy, encouraging green processes, and utilising green products and services.
11th Malaysia Plan (2016-2020)	*'Pursuing green growth for sustainability and resilience.'* Focus on public projects to lead the charge on sustainable practices. Sustainable Consumption and Production (SCP) Blueprint. "GGP will create demand from the public sector for green products and services, encouraging a rise in industry standards to meet sustainability requirements."
12th Malaysia Plan (2021-2025)	"Advancing Green Growth for Sustainability and Resilience." Enhancing Implementation Mechanisms for Green Practices." "A short-term action plan and a guideline on government green procurement (GGP) on works will be introduced to encourage green practices in the construction sector." "Government green procurement initiative will also be implemented in Sabah and Sarawak as a catalyst in expanding the green market, including the green construction sector."
The MyHijau Program (2012)	"A platform to encourage green technology and green purchasing under the Ministry of Energy, Green Technology and Water (KeTTHA) and the Malaysia Green Tech Corporation (MGTC)." SIRIM's Eco-Labelling Scheme.
Government Green Procurement (GGP) Guidelines (2014)	

	GGP Short-term Action Plan (STAP) is an initial step towards GGP implementation in Malaysia. Purchasing is delineated to six (6) green products and services, including cleaning services, ICT equipment, energy efficiency (EE) indoor lighting, paper, paints, and fibre cement (Kahlenborn et al., 2014). The action plan has been endorsed on the 11th of July 2013 by the GGP Steering Committee (SC), chaired by the Ministry of Finance (MOF) and the Ministry of Energy, Green Technology and Water (KeTTHA).
Government Green Procurement (GGP) Guidelines 2.0 (2018)	 "20 GGP criteria for green products and services, such as ICT equipment, air-conditioning systems, and cleaning services. The core team in charge of GGP is led by the Ministry of Finance and the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC)."
Government Green Procurement (GGP) Guidelines 3.0 (2020)	 More than 30 product groups: paper, textile, air-conditioning system, fiber cement, etc. 25 ministries/government agencies.
Construction Industry Transformation Plan (2016-2020)	Focus on public projects to lead the charge on sustainable practices. The CITP will raise sustainability standards for construction, with a focus on public projects, to improve its procurement specifications, resource allocation, and resource performance. Changes in public sector procurement to increase sustainability elements in its specifications and Bill of Quantities in line with sustainability rating tools.

National SCP Blueprint (2016-2030)	"A comprehensive long-term vision and guidance for Sustainable Consumption and Production in Malaysia." Leading by example through government green procurement. Transparency of SCP benefits for private households. The business case for SCP in industry is geared towards a circular economy waste system. Energy-wise buildings. Connecting people through low carbon mobility. Sustainable, safe, and nutritious food, adding value to tourism through SCP, communication, education, and public awareness (CEPA) for SCP. Coordinating and monitoring SCP implementation.
Green Technology Master Plan Malaysia (2017-2030)	Five Strategic Trusts for Development of Conducive Ecosystems for Green Technologies Growth Market Enablers Government Green Procurement (GGP) Green Incentives Innovative Financing Green Cities International Collaborations
National Construction Policy (2030)	**Thrust 2: Embrace Sustainable Built Environment** Development Planning Implementation of design Green Procurement Construction management method Operation and maintenance of assets Asset management Renovation and demolition Low carbon development **Thrust 6: Strengthening Good Governance and Adoption of Best Practices** To improve procurement systems for public projects. "Implement Government Green Procurement (GGP) in government procurement exercises to ensure protection of the environment, reduction of pollution, and conservation of resources are preserved."

Based on Table 3, which highlights government policies and green initiatives, these available policies focus on sustainability and green growth, thereby guiding construction projects to integrate environmental considerations into their operations. The policies promote the use of green technologies and practices that will enhance the overall sustainability of construction activities. As for the National SCP Blueprint and Green Technology Master Plan, these documents provide long-term vision and strategic direction for sustainable consumption and production. It outlines the importance of green procurement and integration of green practices in construction, providing a comprehensive framework for stakeholders to follow. Specific initiatives and programs, such as the MyHijau Program, encourage the adoption of green technology and green purchasing by offering platforms and incentives. Moreover, it helps to raise awareness and facilitate the transition to

greener practices among construction stakeholders. For example, SIRIM's Eco-Labelling Scheme is one of the certifications under MyHijau Marks, which provide certification for green products to help construction stakeholders identify and choose environmentally friendly products and services. There are available government green procurement guidelines to set clear standards and criteria for green products and services. This is to help construction stakeholders understand which green products and services comply with environmental standards.

One of the challenges in implementing green procurement is that it results in higher costs [18]. Therefore, funding support is crucial, and the government must have a strategic plan for providing financial support for green initiatives by the construction stakeholders, such as grants, subsidies, and tax incentives. This will encourage the adoption of green procurement practices in construction. Currently in Malaysia, in line with the Malaysian Government's agenda to drive green growth, Green Technology Tax incentives are introduced, such as Green Investment Tax Allowance (GITA) Projects, Green Income Tax Exemption (GITE) Services for companies that undertake qualifying green technology projects, and Green Technology Financing Scheme [19]. However, the incentives and schemes specifically target green technology, not green procurement. By introducing financial support mechanisms for green procurement, it will encourage green initiatives in the construction sector. Government policies, initiatives, and incentives collectively create an enabling environment for green procurement in construction. They provide clear guidelines, financial support, resources, and a framework for implementation and monitoring, which help stakeholders adopt and integrate green practices in the construction projects.

Regarding the role of the construction industry in green procurement, it is the responsibility of construction stakeholders to translate the policy into actions. Construction stakeholders can incorporate green procurement practices that suit the clients and project needs. During the inception and planning phase, it is recommended to include sustainability tools according to the projects, such as the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST) or Penarafan Hijau JKR (pH JKR) for government projects. Furthermore, construction stakeholders can implement green procurement practices by purchasing products and services that are environmentally friendly, as well as incorporating sustainable construction methods and technologies. Additionally, the industry can develop and adopt new technologies and practices that can enhance sustainability in construction projects [20]. These practices are crucial in addressing the environmental impacts caused by construction activities. By prioritising sustainability throughout the procurement process, construction stakeholders can drive a positive change towards a more environmentally conscious industry. To foster the growth and development of green procurement practices, construction stakeholders can invest in various sustainable projects and technologies [21]. This includes the investment of green building index (GBI) certified projects that use sustainable materials, green products, energy-efficient systems, smart building technologies such as building automation systems, water efficiency technology such as rainwater harvesting systems, and more. With this investment, the construction industry will promote green procurement practices and contribute to sustainability goals and environmental protection. The integration of green criteria in the construction phase is important to encourage the use of green products among construction stakeholders in accordance with MyHijau Marks.

The next main actor in driving green procurement is academia, which represents a knowledge hub. Their role is important to spread awareness and disseminate knowledge on green procurement to construction stakeholders through research, training, and education programs [22]. It is important for academic institutions to conduct research on green practices in construction, green materials, and innovative technologies [23]. This will provide more evidence for effective green procurement implementation. Moreover, research and development of sustainable technologies can be further

enhanced by universities and research institutions with government support, which will contribute to the development of new technologies and methodologies that support green procurement in construction. This can, in a way, drive adoption and promote innovative technology in the construction sector [24]. The research contributed by academia can help bridge the gap between theoretical concepts and practical applications, ensuring that construction stakeholders are well-informed and capable of adopting green procurement. Academia and industry collaboration can effectively drive green procurement, with joint research initiatives, industry partnerships, and internships ensuring a close link between academic research, education, and industry needs. This collaboration can also facilitate the transfer of knowledge from academia to industry, helping overcome the barriers to adopting new technologies and practices. However, the collaborations can be challenging due to differing priorities and timelines between academia and industry. Academia may prioritise long-term research goals, while industry often seeks immediate, practical solutions. Balancing these differing objectives requires effective communication and mutual understanding.

Civil society is the last actor in the green procurement implementation. Civil society organisations advocate sustainable practices and policies, as well as raise awareness on the importance of sustainability [25]. This can also be applied for green procurement in construction. Through campaigns and initiatives, these groups can educate the public on the benefits of sustainable construction and green procurement to encourage community support and stakeholder participation. Civil society can engage with communities to ensure that their needs and concerns are addressed in the development of construction projects. [26] in their research included the civil society approach by looking at the potential role of sustainable public procurement in the 2030 agendas. This can be seen as one of the initiatives and strategies to drive the green procurement implementation in the construction industry. In Malaysia, there are civil society organisations, such as the Environmental Protection Society Malaysia (EPSM) and the Malaysian Nature Society (MNS), which have been active in promoting environmental awareness and sustainability. Although their focus is broader, such as climate change or biodiversity, they indirectly support green procurement practices by emphasising the importance of sustainable practices across various sectors, including construction. Civil society plays a critical role in the green procurement landscape, and in Malaysia, civil society organisations have made significant progress in promoting green and sustainable practices and policies, even though challenges related to resources, influence, and engagement persist. For civil society to maximise its impact, stronger collaboration with the government, industry, and academic institutions is needed, along with sustained efforts to raise public awareness and drive policy change. Industries responsible to promote a wide range of technological and economic advancements for their key stakeholder, society, and implement initiatives that enhance public awareness of sustainability related issues [27].

The nexus Quadruple Helix model, which involves four main actors: the Government, Industry, Academia, and Civil Society, summarises these factors. Each stakeholder plays a crucial role in driving green procurement in the construction sector.

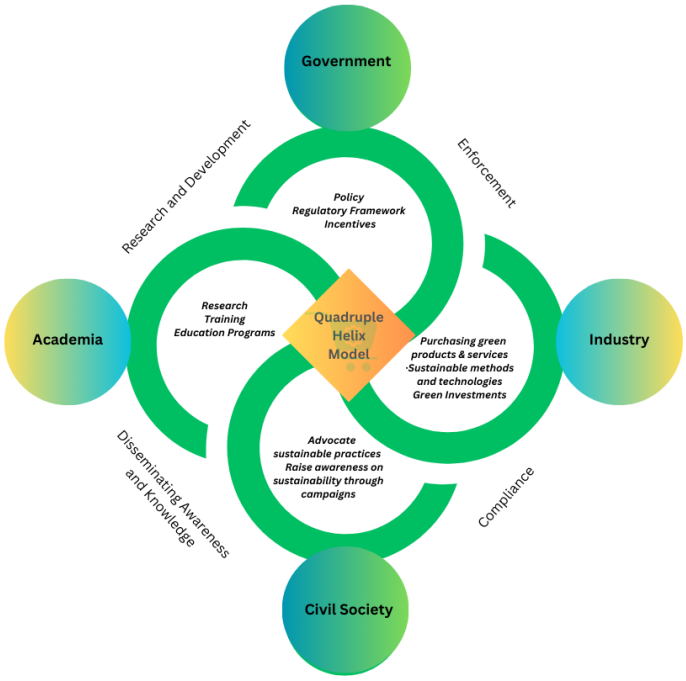

Fig. 1. The Quadruple Helix for green procurement implementation

5. Conclusions

In conclusion, using the nexus Quadruple Helix model for green procurement implementation, these stakeholders can work collaboratively to drive green procurement in the construction sector. Their combined efforts lead to the development of comprehensive strategies and practices that are environmentally sustainable, economically feasible, and environmentally socially responsible. This integrative approach ensures that the transition to green procurement is holistic and effective, enhancing the strengths, roles, and resources of each stakeholder. From the enforcement, disseminating awareness and knowledge, research and development, and compliance, the Quadruple Helix Model serves as a basis framework that unites diverse stakeholders in shaping a greener and more sustainable future for construction projects, while also contributing positively to the global goals of sustainable development.

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