Jurnal Kejuruteraan 38(1) 2026: 53-64
https://doi.org/10.17576/jkukm-2026-38(1)-06

Determinant Criteria for Green Procurement Implementation Strategies (GPIS) in Building Retrofitting Works in Sarawak

Nur Faizah Haratono[a] , Natasha Khalil[b*] & Asmah Alia Mohamad Bohari[c]

[a]*Centre of Graduate Studies, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus, 32610 Perak, Malaysia*

[b]*Faculty of Built Environment, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus, 32610 Perak, Malaysia*

[c]*Faculty of Built Environment, Universiti Teknologi MARA, Sarawak Branch, Kota Samarahan, 94300 Sarawak, Malaysia*

**Corresponding author: natas582@uitm.edu.my*

Received 4 June 2025, Received in revised form 2 October 2025
Accepted 2 November 2025, Available online 30 January 2026

ABSTRACT

Green procurement plays a crucial role in fostering sustainability in the construction industry by addressing the lifecycle impacts of goods and services. In Sarawak, where lies the architectural landscape includes numerous heritage structures, building retrofitting works aligns with the Sarawak Post COVID-19 Development Strategy (PCDS) 2030, emphasizing sustainable development through circular economy and cultural preservation. However, the implementation of green procurement in retrofitting works faces challenges due to inadequate guidelines, a fragmented supply chain, and a short-term focus that overlooks long-term benefits. To address these issues, this study has adopted a bibliographic review technique utilizing various literature compiled from leading databases including Scopus, Web of Science and Google Scholar. It aims to identify the criteria as implementation strategies in adopting green procurement for retrofitting projects in Sarawak. The findings indicated that there are ten (10) strategies (independent variables) that can be considered in implementing green procurement for building retrofitting works (dependent variables). The criteria are identified as Carbon Footprint Analysis (CF), Green Purchasing (GP), Lifecycle Considerations (LC), Reduced Operational Costs (RO) and Stakeholder Capability (SC). The discussion summarized its relevance to the building retrofitting context with a final construct of conceptual framework relating both IVs and DVs. The findings suggest that stakeholders, policymakers, and practitioners need to recognize these main factors to achieve better sustainability and efficiency in building retrofitting works.

Keywords: Green procurement; implementation strategies; building retrofitting; retrofitting projects; bibliographic review

INTRODUCTION

Sustainability in construction has become a critical priority as the industry seeks to minimize its environmental footprint, conserve resources, and promote long-term socio-economic well-being. One of the key approaches to achieving sustainability is through green procurement, which involves the acquisition of goods, services, and works that consider environmental and social impacts alongside traditional economic criteria (Mi 2024). Green procurement is a fundamental method in the construction industry that seeks to avoid the adverse environmental social and financial impacts of getting purchased items and services throughout their lifecycle (Khan et al. 2018). Malaysia has ambitious goal in leveraging the green procurement agenda since 2014 and currently the implementation is widen to states including Sarawak.

The Sarawak Post COVID-19 Development Strategy (PCDS) 2030 (2021) places an emphasis on the importance of supporting circular economies in the provision of sustainable building development. Local stakeholders in Sarawak can follow greener construction practices that are intended to help realise the sustainability plans of Malaysia and Sarawak, including the Twelve Malaysia Plan (2021-

2025) and the PCDS 2030. In the context of building retrofitting, green procurement plays a vital role by ensuring that materials, technologies, and services used in upgrading existing structures align with sustainability goals. However, despite the existence of national strategies, green procurement practices in retrofitting remain fragmented, lacking effective implementation strategies tailored to regional contexts like Sarawak. Ideally, exploring green procurement first also helps identify suitable suppliers, sustainable alternatives, and compliance with environmental regulations, which can prevent costly redesigns or adjustments later.

WHAT IS GREEN PROCUREMENT?

Green procurement refers to the process of purchasing goods, services, and works that take into account environmental criteria and standards in order to protect the environment and natural resources, while also minimising or preventing the negative effects that are caused by human activities (MyHIJAU 2018). Green procurement is a method that is regarded to be rising in popularity within the construction industry. This practice is centered on addressing environmental concerns and improving the overall sustainability of the sector (Khan et al. 2019). The fundamental objective of implementing green procurement is to improve overall performance and to push the organization to adopt practices that are more ecologically friendly (Rasheed et al. 2024).

In Malaysia, green procurement has been adopted as one of the measures to sustainable development agenda. The Treasury Circular 1.9 issued by Ministry of Finance in November 2022 is a key policy that mandates green government procurement (GGP) for nine specific product groups, including Information and Communication Technology (ICT) equipment, air conditioning, and solar energy systems (Treasury Circular 1.9, 2022). This policy is meant to improve environmental responsibility and standards in public sector procurement of products and services. Additionally, the Malaysian Green Technology Corporation (MGTC) has also provided a guideline as a way of encouraging green procurement. They promote the adoption of green products and solutions in several different industries such as construction (MGTC, 2020). Nevertheless, these guidelines are not optimized for the building retrofitting projects which need specific solutions to address the problem of energy efficiency and sustainability successfully (Soto et al. 2020). The current established guidelines is lacking in addressing the criteria needed and process of upgrading old buildings and retrofitting needs.

According to Kwasafo et al. (2024), green procurement for construction projects is a noble effort to reduce the negative effects on the natural setting in the processes and stages of the project. The term green procurement is used in a way that is akin to the consequences of the procurement decisions on the environment. Environmentally responsible purchasing has the potential of reducing the quantities of valuable resources that get used, the amount of waste that are generated and also improve on the environmental management of construction works. Green procurement aims at providing priority to those goods and services that will help to reduce the detrimental effects on the environment in attempts to enhance sustainable usage of resources (Ngubane, 2024).

According to Sandra et al. (2022) the use of environment friendly materials and technologies will help to lower the levels of carbon emissions, energy and water usage. It is applicable in eradicating climate change by choosing products and services that have lower impact on the environment and in supporting new technology and energy sources that have minimal effects to the environment (Singhal et al, 2024). In the realm of procurement procedures, green procurement is another effective best practice in the field of procurement practices which allows managing various negative consequences of products and services during their life cycle.

Bohari et al. (2015) stressed that green procurement is crucial in adjusting the consumption and production paradigms of products and services to meet the sustainable policies. Environmental accountability is defined as the enhancement of the application of environment practices or systems (Kwasafo et al. 2024) that aimed at minimizing the environment factors of a product at the production, usage and disposal phases (Khan et al. 2018). This indicates that green procurement includes environment friendly ideas and innovations for sustainable development in the construction phase. However, as of now, there is no specific available standard rules on green procurement that specifically pertain to the building industry (Razali et al. 2021). It strongly advocated for an elaboration of more comprehensive policies and policies focused on the construction and building industry particularly the construction industry to enhance the procurement of green products that can positively impact the achievement of the goals of environmental sustainability and sustainable development generally. Ideally, green procurement can support greener goals in retrofitting works.

BUILDING RETROFITTING WORKS

Building retrofitting is the process of altering a structure, with the objective of maximizing the use of energy in an

efficient way, enhancing ecological performance, and longevity (Prajapati, 2023). This process is even more crucial bearing in mind the issue of sustainability, climate change and development. The main goal is to reduce energy consumption and greenhouse gases emission and in doing so increase the sustainable forms of buildings (Sharma et al. 2022). Actual improvements carried out in enhancing the performance of the building are generally termed as retrofitting and these focuses on enhancing the energy efficiency of the buildings. Improving insulation, employing double-glazed windows, and adopting modern HVAC systems can minimize energy consumption (Akram et al. 2023).

Retrofitting also emphasizes on enhancing of indoor environment quality. It could be in the aspect of enhancing the fresh air distribution, employing materials that are not harmful to the air that the occupants breathe and adequate natural ventilation that ensures comfort to the occupants (Trofimova et al. 2021). Retrofitting involves bringing improvement to the existing intensity of energy saving as well as the environmental functions of built assets, reducing cost and mitigating effects on environment and health of occupants (Weerasinghe et al. 2024). There are several factors that have led to building retrofitting in Malaysia include; energy conservation, minimization of greenhouse gas emission, and enhanced indoor environment quality.

However, building retrofitting works also faces several issues. Amoah and Smith (2024) revealed that a major drawback in retrofitting works is high initial cost and technological factors, which incur failures in operational maintenance of building. The next section of this paper entails the issues relating to building retrofitting works thus fostering why green procurement is needed in this process.

PROBLEM STATEMENT

As mentioned previously, Treasury Circular 1.9 (MOF 2022) has mandated the GGP adoption for all public agencies in Malaysia. Despite the fact that the circular requires all agencies to fully integrate GGP for the procurement of nine (9) particular product and service groups, the policy is not specifically aligned to construction works and retrofitting operations. As for now, there is no clear policy or established guidelines to implement GGP for building construction or retrofitting works. Since retrofitting involves working within existing structures and often requires unique materials and technologies (Shahi et al. 2020), the absence of guidelines complicates the actions of the stakeholders and their ability to choose appropriate green materials and technology for retrofitting, which causes the inconsistency of green procurement practices.

In the construction sector, many organizations are not keen to collaborate with other organizations, leads to improper communication or cooperation (Fellows & Liu, 2012; Mehran et al. 2022). This leads to inefficient decisions, conflicts and confusion regarding the use of the sustainable materials and practices (Vejaratnam et al. 2020; Wilson & Rezgui, 2013). Moreover, supply chains for green materials and technologies are not always well-established in Malaysia (Shaharudin et al. 2022), thus occurs a fragmented supply-chain. Suppliers and manufacturers often lack awareness of green procurement standards and specifications, making it difficult to source environmentally friendly products at reasonable costs (Ashraf et al. 2020). Issues such as poor accessibility and distribution of green products must also be considered perceptually, this make the adoption and implementation of green products more complex (Sallnäs & Björklund, 2023). This overall fragmentation in the supply chain leads to time delays, excessive costs and inability to achieve the overall targets of sustainability within retrofitting projects (Khan et al. 2019). Therefore, more integration of stakeholders and creation of better supply chain is needed to ensure a better practice in green procurement is feasible in retrofitting.

Another constraint is the lack of long-term perspectives among the decision-makers or construction stakeholders. Short-term mentality can be realized particularly in retrofitting projects, in which sustainable capital investments such as energy-efficient systems, and environmentally friendly materials offer ideal returns in the future in terms of operating costs, conserving energy, and emissions of greenhouse gases (Iliyana et al. 2023). When it comes to the integration of green procurement measures, stakeholders that look for products and services such as building owners or project managers may resist change due to the belief that environmental-friendly construction is costly. But this particular notion omits the overall life cycle cost perspective of environmental procurement in the procurement system. Installing an energy-efficient options with better-quality insulation on the roofing and walls will have initially high costs than their traditional counterparts. However, the total cost of ownership, energy costs as well as carbon emission in the whole building life are considerably reduced (Birkha Mohd Ali et al. 2021).

Unfortunately, the gratification in the short-run financial returns, tend to lead to the choice of cheaper or inferior materials that are not environmentally friendly, thus slowing down green procurement initiatives. The prevailing models of building procurement for the construction industry fail to consider long-term impact since they are mostly influenced by cost and time factors (Mojumder et al. 2022). It is also supported by the absence of significant financial incentives or legal obligation for suppliers and buyers to undertake plans towards sustainable

procurement (Bidin et al. 2022; Taghizadeh-Hesary & Yoshino, 2020). It is especially important to address these issues in Sarawak due to infrastructure development under PCDS 2030 is rapidly expanding the state. By putting green procurement measures in place, the impact of many public and private buildings needing retrofitting can be reduced by saving energy, lowering carbon emissions and contributing to sustainable growth. In addition, developing strong green procurement in Sarawak can serve as a model for other regions in Malaysia dealing with similar challenges.

Green procurement implementation needs to provide specific strategies towards significant impact on building retrofitting works in Sarawak is essential to identify the implementation of green procurement in the Malaysian construction industry. This study findings will not only fill the existing loopholes in green procurement but also provide considerable relevance to stakeholders, project team and others. Therefore, the aim of this research is to determine the green procurement implementation strategies (GPIS) for building retrofitting works. Based on the determinant criteria of GPIS, stakeholders able to see the impact to building retrofitting works through sustainable materials, promote resource efficiency, and encourage the use of eco-friendly construction practices. This not only supports regulatory compliance and environmental responsibility but also drives innovation and long-term cost savings, making green procurement a fundamental component of sustainable retrofitting efforts in the built environment.

METHODOLOGY

This paper is part of an on-going study and at current, the study has finalised the analysis and synthesis of literature review. The criteria of GPIS and the impact on building retrofitting works by adopting green procurement in Sarawak were compiled from literature review using bibliographic analysis. The bibliographic review is generally carried out to locate, analyze and categorize the applicable academic sources in respect to this research topic (Sánchez-García et al. 2018). The review collates a large number of research articles, industry reports and policy documents from major databases Scopus, Web of Science, ScienceDirect and Google Scholar to give a clear outline on GPIS criteria are applied and significant for the construction and sustainability sectors. Keywords used in the search include “green procurement”, “building retrofitting”, “sustainability” and “construction industry”. Sánchez-García et al. (2018) mention that this approach reveals how key ideas have developed as time has progressed. As supported by Linnenluecke et al. (2019), this approach enables the researcher to uncover how work patterns have driven certain key contributions to the field, while tracing the progress of scholarly thought in this same context. The review focuses on the bibliographic data such as the author contributions, the publication trends, and the citation networks and offers the snapshot of how one research topic gained leverage over others (Mardiani et al. 2023); the impact of particular research fellows; and the emergence of theoretical paradigms in the discipline. This method gives the researchers the opportunity to source and categorise materials in a structured fashion, which enables researchers to have a clear idea of the scope of that which does already exist, and how that study fits into that scope (Ocaña-Fernández & Fuster-Guillén, 2021). This method is especially valuable for identifying gaps in current research, thereby providing direction for future investigations. This research is founded on a critically important literature review of existing knowledge regarding Green Procurement Implementation Strategies (GPIS) and their potential role in building retrofitting projects, specifically in Sarawak. Hence, the review aims to achieve:

1. identification of the green procurement implementation strategies criteria for building retrofitting works (independent variables)
2. the impact on building retrofitting works by adopting green procurement (dependent variables).

ANALYSIS AND DISCUSSION OF FINDINGS

The analysis of bibliographic review has compiled the implementation strategies into three sustainable pillars: i) environmental criteria, ii) economic criteria and iii) social criteria. Specifically, five (5) strategies were identified under environmental criteria, two (2) under economic criteria, and three (3) under social criteria. It was found that there are ten (10) strategies as criteria that can be considered in implementation green procurement for building retrofitting works. Identifying these criteria is crucial, as it provides stakeholders with the information needed to make informed decisions regarding green procurement implementation. Table 1 summarised the listed criteria followed by discussion on its suitability as GPIS.

TABLE 1. Description of Green Procurement Implementation Strategies (GPIS) Criteria

Sustainable Pillar	Item	GPIS Criteria	Description of Implementation	Source(s)
Environmental Criteria	1	Carbon footprint analysis (CF)	Carbon footprint analysis measuring and reducing carbon footprint related to procurement activities to promote sustainability	(He et al. 2022; Lingegård et al. 2021)
	2	Green purchasing (GP)	Green purchasing focuses on sourcing of items that minimize on their impact on the environment, considered as environmentally friendly	(Slastanova, Hlodak, et al. 2021)
	3	Green specification (GS)	Green specifications entail that environmental concerns must be incorporated in procurement agreements in form of provision for use of recycled products or energy efficient products.	(Piga & Treumer, 2013; Szewc & Szymańska, 2023)
	4	Policy and legal framework (PLF)	Policy and legal framework for mandating or encouraging the adoption of green procurement practices	(Bostan et al. 2020; Mélon, 2020)
	5	Lifecycle considerations (LC)	Lifecycle considerations associated with the analysis of the environmental, virtual, and social consequences of the material, product, or system living cycle	(Grigoropoulos et al. 2021; Weldu & Al-Ghamdi, 2019)
Economic criteria	6	Comprehensive budget (CB)	A comprehensive cost estimation that needs to factor costs of different stages of a project and delivery to align with set sustainability objectives within the available resources	(Elasto et al. 2023; Orieno et al. 2024)
	7	Reduce operational costs (RO)	Cutting down on ongoing costs through green technologies leads to long-term savings that improve return on investment (ROI) for stakeholders.	(Orfanidou et al. 2023)
Social Criteria	8	Stakeholder capability (SC)	Stakeholder capability refers to the collective knowledge, skills, resources, and collaboration needed by all involved parties to effectively implement green procurement strategies in sustainable building projects	(Bohari et al. 2023)
	9	Supplier inclusivity (SI)	Sourcing relevant suppliers so that the supply chain can contain a spread of equal opportunities to encourage sustainable innovations	(Gujar, 2024)
	10	Workforce training and awareness (WT)	Training of the stakeholders in sustainability to enable the firm in the implementation of green procurement principle.	(Bohari et al. 2020; Payne et al. 2012)

Discussion of findings are entailed as follows:

1. Carbon footprint analysis (CF)

   Carbon footprint analysis is an important tool in the management of climate change impacts since it seeks to identify the total amount of greenhouse gas emissions from a product/life cycle or system throughout its life cycle (Zima, 2021). This assist in establishing means of minimizing emissions whereby low carbon materials and systems for building retrofitting are chosen. Optimization of carbon emissions of various systems give priority to low emission, energy efficient technologies (Dalene, 2012). This reduces the building's operational energy demand, leading to lower energy consumption. According to Olatunde et al. (2024), significant cost savings, efficient energy consumption and enhanced indoor environment quality are consequences of deploying energy-efficient HVAC technologies.

HVAC systems that become efficient in energy use as well as emissions during operation. In spite of its benefits, practical implementation may depend on using advanced tracking tools and stakeholders training in Sarawak.

2. Green purchasing (GP)

Procurement of goods and services that meet specific environment criteria, such a s production from recycled materials, energy efficient, or low environment impact all the way through its life cycle, is known as green purchasing (Cota et al. 2018). Through this strategy, eco-friendly products are encouraged for use in building retrofitting. Green purchasing in construction and retrofitting is the selection of energy efficient products and material for overall sustainability improvement. It involves purchasing Energy Star rated appliances, as well as other energy saving equipment (Bunch & Payne, 2016). Energy efficient lighting, solar collectors, and low emission glazing are green retrofits that provide saving in energy consumption, CO2 emissions and operating costs (Weerasinghe et al. 2020). However, the availability and cost of certified green products may limit adoption, especially in rural regions.

3. Green Specifications (GS)

Green building specification and rating systems serve as baseline for supporting sustainable construction by lowering environmental impacts (Chodnekar et al. 2021). Typically, criteria of these systems include energy efficiency, passive design, integration of renewable energy, and resource conservation (Chodnekar et al. 2021). By specifying in this way, sustainability goals are maintained over the entire procurement and retrofitting process.

Green specifications are essential to facilitating sustainable practices in different sectors. Green specifications foster innovation in suppliers and manufacturers and will result in the product development of more environmentally friendly product and system (Lee & Kim, 2011). These specifications have guided architects and engineers in the design of environmentally sensitive and energy-efficient building forms (Bu & Shen, 2013). In practice, limited familiarity with green specification standards can lead to their ineffective use during procurement.

4. Policy and legal framework (PLF)

A good and appropriate policy and legal framework of all the procurement activities is such that all procurement activities are friendly with its environmental laws and sustainability goals (Caranta, 2023). Government regulations, government guidance and incentives relating to building retrofitting with green technologies and practices may be contained in this framework. In retrofitting projects, minimum energy performance standards are often promulgated that stipulate the use of only energy efficient technologies. Such acceleration of the diffusion of energy efficient technologies and the closing of the energy efficiency gap is achieved by policies (Schwarz et al. 2019).

Green procurement can be made more cost effective when it comes to a clear legal framework that offers financial incentives in the form of tax rebate or grants to offset the cost of energy efficient technology (Mélon, 2020). According to Brotman (2014), green certification tax incentives that can help offset the upfront costs. In Sarawak, regulations are sometimes carried out differently which results in inconsistency. It is important that incentives are straightforward and well known to encourage more people to use them.

5. Lifecycle considerations (LC)

Lifecycle considerations associated with the analysis of the environmental, virtual, and social consequences of the material, product, or system living cycle (Grigoropoulos et al. 2021; Weldu & Al-Ghamdi, 2019). This includes extractions of raw material, manufacturing, distribution, use/ utilization, and lastly replacement through discharge or recycling (Testa et al. 2011). Thus, the choices made have values that last a life cycle hence the orientation towards sustainability, durability and performance of a retrofitting project.

Taking a life cycle approach, energy efficient construction materials and infrastructure technologies are incorporated that reduce energy demand at operational stages of the building (Abejón et al. 2020). Selecting high performing insulation materials and design that minimizes heating and cooling needs throughout the duration of the building (Qayyum Nazri et al , 2015). For instance, product development of biodegradable materials or products containing recycled content that cause less harm to the

environment during manufacturing and at the time of their disposal (Fouad & Farag, 2019). However, reliable lifecycle data and analysis capabilities may be limited for local stakeholders.

6. Comprehensive budget (CB)

According to Elasto et al. (2023), a comprehensive budget is a detailed breakdown of fiscal resources assigned to all stages of a green procurement project, right from the commencement of the project and even beyond into the long term period, with both initial and long-term fiscal costs taken into account. Robichaud & Anantatmula (2011) defines it as funding for planning, implementation, monitoring and evaluation with a view of meeting sustainability goals and maximizing economic outcomes. During retrofitting projects, it is necessary to figure out a detailed budget, which will allow launching of the installation of different energy efficient technologies (Sharma et al. 2022), like better insulation, energy efficient windows, and high efficient heating and cooling systems. The more these investments enhance the building's energy performance, and the more they effectively reduce the building's energy consumption in the long term as well as lower operating costs, the better for sustainable retrofitting (Olatunde et al. 2024; Sharma et al. 2022). Budgeting can be limited by upfront costs and the challenge of justifying long-term savings, especially in projects with tight financial constraints.

7. Reduce operational costs (RO)

Operational costs reductions involve minimisation of ongoing expenses (Amaral et al. 2020a) that are related to energy, water and waste management by means of the use of sustainable materials and energy efficient technologies during the retrofitting projects. The adoption of innovative green technologies is often motivated by reducing operational costs that generate long-term savings and sustainability (Lutfi et al. 2023; Redzhepov et al. 2024). This lead to reduce waste and lower costs with advanced energy management systems that monitor, and if possible, to optimize energy usage. This leads to higher return on investment (ROI) for stakeholders, as improved financial results, more savings and spending rationale for green technology give a boost to ROI. Yet, stakeholders may need training to accurately assess and quantify such returns.

8. Stakeholder capability (SC)

Stakeholder capability can be defined as the skills, knowledge, resources and collaboration of all parties involved (Bohari et al. 2023; Liang et al. 2015) such as contractors, suppliers, consultants, and regulators required to support effective green procurement strategies to retrofitting project. Stakeholders with knowledge of green technologies and financial awareness (Mottaeva et al. 2023), can do more cost effective choices by comparing long terms saving from sustainable materials and technology. Some stakeholders may use to perform life cycle cost analysis to choose energy efficient systems which will save operational cost. Retrofitting projects have the potential to get lower levels of carbon footprints with the help of stakeholders that can understand and use carbon reduction technologies (Ahmed et al. 2023). Building such capability requires ongoing education and institutional support.

9. Supplier inclusivity (SI)

Green procurement supplier inclusivity is about how to involve a wide range of suppliers, such as small and medium enterprises (SMEs), or minority, or women owned businesses, or even local suppliers, in the procurement process (Gujar, 2024). It guarantees that decisions made in procurement regarding buying goods and services include a process of social equity as well as environmental sustainability. Supplier inclusivity provides for a broader range of suppliers providing innovative (Ngari & Namusonge, 2023; Olutimehin et al. 2024), energy efficient solutions specific to building retrofit. Promoting inclusivity could enhance local capacity and sustainability in Sarawak. However, local and smaller suppliers typically produce more region specific, energy efficient products and services which help to retro fit buildings to meet modern energy standards (Brocklehurst et al. 2021). Diversification of the supplier base affords organizations access to more energy saving technologies which improve the energy performance of retrofitted buildings.

10. Workforce training and awareness (WT)

Training of the stakeholders in sustainability in order to assist the firm to be in a position to implement the green procurement principle (Bohari et al. 2020; Payne et al. 2012). Green procurement can be improved with training programs and awareness campaigns, enhanced

through the promotion of best practices, and made consistent throughout the life of a project if sustainability goals are embedded throughout. The training programs elevate the awareness of the latest green techniques and innovative solutions that the workforce can be acquainted with to use sustainable products and behaviors for the retrofitting projects (Neto et al. 2014). If workers have better knowledge of emerging green technologies, they can help to incorporate advanced materials and systems, such as energy efficient lighting, renewable energy systems, and low impact construction processes. Practical challenges include program funding and ensuring training reaches all relevant participants.

Based on the above discussions, the bibliographic analysis is summarised in accordance to the frequency attainment of the criteria, as shown in Table 2.

TABLE 2. Determinants of Green Procurement Implementation Strategies (GPIS) Criteria through bibliographic review

Bibliopraphy / Source(s)	CF	GP	GS	PLF	LC	CB	RO	SC	SI	WT
Blome et al. (2014)									Ö	
Bidin et al. (2018)	Ö				Ö		Ö	Ö		
Cheng et al. (2018)					Ö			Ö	Ö	Ö
Khan et al. (2018)		Ö						Ö		
Ezani et al. (2018)	Ö	Ö		Ö	Ö		Ö			
Wang et al. (2018)			Ö			Ö				Ö
Appolloni et al. (2019)										Ö
Ghosh (2019)		Ö							Ö	
Becker (2020)									Ö	
Anuar et al. (2021)	Ö		Ö		Ö		Ö	Ö		
Chan et al. (2021)			Ö							
Puspitasari & Glennardo (2021)			Ö				Ö	Ö		
Casier et al. (2022)	Ö									
Bidin et al. (2023)		Ö					Ö			
Elasto et al. (2023)						Ö				Ö
Orfanidou et al. (2023)		Ö				Ö	Ö			
Yang et al. (2023)				Ö						
Bohari et al. (2024)				Ö		Ö		Ö		
Gujar, (2024)									Ö	
Nazir et al. (2024)		Ö			Ö					
Singh et al. (2024)	Ö	Ö		Ö	Ö					
Total Frequency	5	7	4	4	6	4	6	6	4	4

The results have revealed that Green Purchasing (GP) is the most emphasized criteria across sources, which highlights its critical role in driving sustainable procurement practices. This suggests that in contexts of Sarawak, where procurement systems are still evolving, GP is seen as an easily accessible and valuable way to use sustainable practices by choosing environmentally certified products or energy-saving materials. The importance of long-term sustainability, financial viability, and human resource capacity in the successful implementation of green procurement strategies highlighted by Lifecycle Considerations (LC), Reduce Operational Costs (RO), and Stakeholder Capability (SC), each of which six (6) frequency. These criteria suggest that stakeholders in Sarawak should focus on how changes benefit the environment as well as the economic and social sectors to make the adoption last over the long term. The slightly lower frequency of Carbon Footprint Analysis (CF) may indicate that while it is recognized as important, it is perhaps more technical or not yet fully recognized in current local practices, highlighting an opportunity for Sarawak to highlight this aspect for better environmental

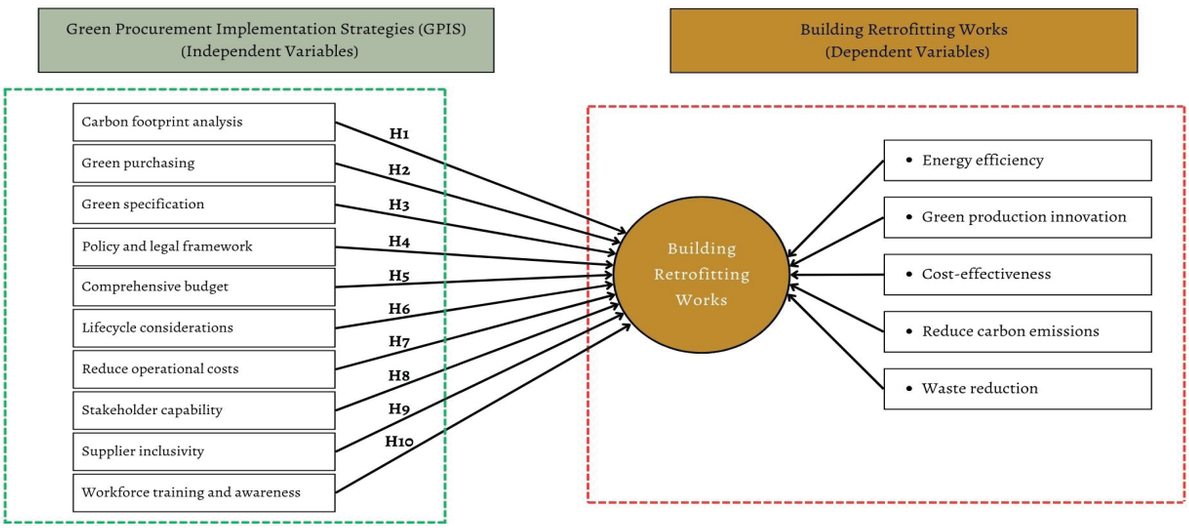
results.

1. To strengthen interpretation, each criterion (independent variable) can be seen as influencing specific dependent variables like energy efficiency, green production innovation, cost effectiveness, reduce carbon emissions and waste reduction. As shown in Table 3, the impact of building retrofitting works from green procurement adoption is justified as follows:
2. Green purchasing in construction and retrofitting is the selection of energy efficient products and material for overall sustainability improvement. It involves purchasing Energy Star rated appliances, as well as other energy saving equipment (Bunch & Payne, 2016).
3. Lifecycle considerations encourage manufacturers to design goods that require low environmental impact over the life cycle of a product cycle (Singhal et al. 2024).
4. Lower carbon emissions are typically a direct consequence of better operational costs and lower energy consumption (Mi, 2024).
5. Stakeholders are more aware of the importance of energy saving retrofits when they are equipped with knowledge about energy saving retrofits based on technologies and materials that lead to more efficient energy saving retrofits (Xie & Liu, 2022).
6. Carbon footprint analysis in green procurement promotes waste and emission reduction across the entire lifecycle of a product (Kryzia et al. 2024).

The decision on the criteria is important as choices secure the provision of green procurement, it has been defined as the intentional identification, acquisition, and utilization of products and services which have visually considered and possibly reduced negative effects on the environment at various stages in their life-cycle, as a critical strategy in promoting sustainability within different sectors. This rather long-term strategic action plan's objectives may also serve to decrease negative impacts on the environment and increase economic rationality as well as social justice in organizations. Based on the criteria determinants, an initial conceptual framework relating the GPIS to the impact of building retrofitting works is displayed with the construct of hypothesis from the IV to the DVs, as shown in Figure 1. The construct hypotheses are raised from the research issues and will be further tested to evident the relevancy of GPIS criteria to building retrofitting impact.

TABLE 3. Summary on the determinants of Green Procurement Implementation Strategies (GPIS) Criteria to the Building Retrofitting impact

Item	Green Procurement Implementation Strategies (IV)	Impact on Building Retrofitting Works by Adopting Green Procurement (DV)
1	Carbon footprint analysis	Energy efficiency Green production innovation Cost-effectiveness Reduce carbon emissions Waste reduction
2	Green purchasing	
3	Green specification	
4	Policy and legal framework	
5	Comprehensive budget	
6	Lifecycle considerations	
7	Reduce operational costs	
8	Stakeholder capability	
9	Supplier inclusivity	
10	Workforce training and awareness	



Legend:
H^1: Addressing Carbon Footprint Analysis in green procurement has a significant impact to the Building Retrofitting Works
H^2: Addressing Green Purchasing in green procurement has a significant impact to the Building Retrofitting Works
H^3: Addressing Green Specification in green procurement has a significant impact to the Building Retrofitting Works
H^4: Addressing Policy and Legal Framework in green procurement has a significant impact to the Building Retrofitting Works
H^5: Addressing Comprehensive Budget in green procurement has a significant impact to the Building Retrofitting Works
H^6: Addressing Lifecycle Considerations in green procurement has a significant impact to the Building Retrofitting Works
H^7: Addressing Reduce Operational Costs in green procurement has a significant impact to the Building Retrofitting Works
H^8: Addressing Stakeholder Capability in green procurement has a significant impact to the Building Retrofitting Works
H^9: Addressing Supplier Inclusivity in green procurement has a significant impact to the Building Retrofitting Works
H^{10}: Addressing Workforce Training and Awareness in green procurement has a significant impact to the Building Retrofitting Works

FIGURE 1. Conceptual Framework of Green Procurement Implementation Strategies (GPIS) to the Significant Impact on Building Retrofitting Works and Hypotheses Construct

CONCLUSION

Based on the review, it can be seen that improvement of the efficiency in energy usage will be enhanced through incorporation of environmental aspects into purchasing decisions, green purchasing promotes new development of green products,. These impacts show that green procurement has a possibility to bring significant changes further stating that it is efficient in enhancing environmental, economic, and social aspects of a society. The findings suggest that stakeholders, policymakers, and practitioners need to recognize these main factors to achieve better sustainability and efficiency in building retrofitting works. The next phase of this study will be delved towards hypothesis testing in validating the relationships between the identified GPIS criteria and retrofitting outcomes. Building on this, future research should also explore how these factors interact in in multiple contexts and also discover new ways for technology to improve sustainable retrofitting.

ACKNOWLEDGEMENT

This research article was financially supported by Universiti Teknologi MARA and Institute of Postgraduate Studies UiTM. The authors would also like to express their appreciation to Universiti Teknologi MARA (UiTM) Library for providing access to the subscribed online library databases that helps in accessing the literature for this study.

DECLARATION OF COMPETING INTEREST

None.

REFERENCES

Amoah, C., & Smith, J. 2024. Barriers to the green retrofitting of existing residential buildings. *Journal*

of Facilities Management 22(2): 194–209. https://doi.org/10.1108/JFM-12-2021-0155

Ashraf, S., Ahmed, T., Saleem, S., & Aslam, Z. 2020. Diverging mysterious in green supply chain management. *Oriental Journal of Computer Science and Technology* 13(1): 22–28. https://doi.org/10.13005/ojcst13.01.02

Birkha Mohd Ali, S., Hasanuzzaman, M., Rahim, N. A., Mamun, M. A. A., & Obaidellah, U. H. 2021. Analysis of energy consumption and potential energy savings of an institutional building in Malaysia. *Alexandria Engineering Journal* 60(1): 805–820. https://doi.org/10.1016/j.aej.2020.10.010

Bunch, S., & Payne, C.T. 2016. Contracting for Efficiency. A Best Practices Guide for Energy-Efficient Product Procurement.

Chen, L., Hu, Y., Wang, R., Li, X., Chen, Z., Hua, J., Osman, A. I., Farghali, M., Huang, L., Li, J., Dong, L., Rooney, D. W., & Yap, P. S. 2024. Green building practices to integrate renewable energy in the construction sector: a review. In *Environmental Chemistry Letters* 22(2): 751–784. https://doi.org/10.1007/s10311-023-01675-2

Fellows, R., & Liu, A. M. M. 2012. Managing organizational interfaces in engineering construction projects: Addressing fragmentation and boundary issues across multiple interfaces. *Construction Management and Economics* 30(8): 653–671. https://doi.org/10.1080/01446193.2012.668199

Hanapiah, N. M., Mohd Zaki, N. I., Abu Husain, M. K., & Mukhlas, N. A. 2022. Green Building in Existing Development: A Review of Current Status, Challenges, and Implementation Strategy. *Civil Engineering and Architecture* 10(7): 3135–3146. https://doi.org/10.13189/cea.2022.100726

Hmidah, N. A., Bin Haron, N. A., Hizami, A. A., Law, T. H., & Altohami, A. B. A. 2023. Energy consumption of retrofitting existing public buildings in Malaysia under BIM approach: Pilot study. *Sustainability* 15(13). https://doi.org/10.3390/su151310293

Hollberg, A., Tjäder, M., Ingelhag, G., & Wallbaum, H. 2022. A framework for user centric LCA tool development for early planning stages of buildings. *Frontiers in Built Environment* 8. https://doi.org/10.3389/fbuil.2022.744946

Ibekwe, K.I., Umoh, A.A., Nwokediegwu, Z.Q., Etukudoh, E.A., Ilojianya, V.I., & Adefemi, A. 2024. Energy efficiency in industrial sectors: A review of technologies and policy measures. *Engineering Science & Technology Journal*.

Iliyana, A., B. S., Bohari, A.A.M., & Khalil, N., 2023. Stakeholder capability criteria of green procurement for construction projects in Malaysia: A systematic review. *Malaysian Journal of Sustainable Environment* 10(2): 97–116. https://doi.org/10.24191/myse.v10i2.23621

Imani, E., Dawood, H., Dawood, N., & Occhipinti, A. 2023. Retrofitting of Buildings to Improve Energy Efficiency: A Comprehensive Systematic Literature Review and Future Research Directions (pp. 1094–1104). https://doi.org/10.36253/979-12-215-0289-3.109

Khan, M. W. A., Ullah, M., & Kuang, C. 2019. Sustainability Through Green Procurement: Interplay Between Leadership and Institutional Pressures. 196–205. https://doi.org/10.15405/epsbs.2019.08.20

Klufallah, M., Othman, I., Nuruddin, M.F., & Khamidi, M.F. 2018. Barriers to sustainable practices towards low carbon emission projects in Malaysia. *International Journal of Engineering & Technology.*

Kryzia, K., Radziejowska, A., & Sobotka, A. 2024. Analysis of factors influencing carbon footprint reduction in construction projects. *Archives of Mining Sciences* 69(2): 327–347. https://doi.org/10.24425/ams.2024.150348

Kwasafo, O. K., Adinyira, E., & Agyekum, K. 2024. Impact of green construction procurement practices on the success of circular economy in Ghana. *Built Environment Project and Asset Management*. https://doi.org/10.1108/BEPAM-06-2023-0109

Lingegård, S., Olsson, J. A., Kadefors, A., & Uppenberg, S. 2021. Sustainable public procurement in large infrastructure projects—policy implementation for carbon emission reductions. *Sustainability* (Switzerland): 13(20). https://doi.org/10.3390/su132011182

Mehran, D., Poirier, E. A., & Forgues, D. 2022. Impact of fragmentation on value generation-towards a bim-enabled lean framework. 30th Annual Conference of the International Group for Lean Construction, IGLC 2022, 1165–1176. https://doi.org/10.24928/2022/0229

Mi, Z. 2024. Sustainable architectural practices: Integrating green design, smart technologies, and ultra-low energy concepts. *Theoretical and Natural Science* 40(1): 8–13. https://doi.org/10.54254/2753-8818/40/20240203

Mojumder, A., Singh, A., Kumar, A., & Liu, Y. 2022. Mitigating the barriers to green procurement adoption: An exploratory study of the Indian construction industry. *Journal of Cleaner Production* 372. https://doi.org/10.1016/j.jclepro.2022.133505

Norazman, N., Salleh, N. M., Mohd Nashruddin, S. N. A., & Wan Ismail, W. N. 2023. Strategic planning of sustainable maintenance in heritage school buildings: Malaysia perspectives. *International Journal of Building Pathology and Adaptation*. https://doi.org/10.1108/IJBPA-04-2022-0060

Ocaña-Fernández, Y., & Fuster-Guillén, D. 2021. The bibliographical review as a research methodology. *Revista Tempos e Espaços Em Educação* 14(33): e15614. https://doi.org/10.20952/revtee.v14i33.15614

Prajapati, D. 2023. Systematic Improvement of Retrofitting Tools Through the Use of Active Projects: A Review (Vol. 13).

Qayyum Nazri, A., Sarrazin Mohammad, I., Baba, M., Nadiah Zainol, N., Amir Afiq Lokman, M., Bee Woon, N., Aqlima Ramli, N., & Bahru, J. 2015. The need for retrofitting to achieve sustainability of Malaysian buildings. *Jurnal Teknologi* 75(10). https://doi.org/10.11113/jt.v75.5286

Razali, N., Khalil, N., Mohamad Bohari, A. A., & Husin, H. N. 2021. Green procurement in construction: Analysis of the readiness level and key catalyst among construction enablers. *International Journal of Sustainable Construction Engineering and Technology* 12(1): 1–11. https://doi.org/10.30880/ijscet.2021.12.01.001

Sallnäs, U., & Björklund, M. 2023. Green e-commerce distribution alternatives – A mission impossible for retailers? *International Journal of Logistics Management* 34(7): 50–74. https://doi.org/10.1108/IJLM-07-2022-0271

Sandra Marcelline, T. R., Chengang, Y., Ralison Ny Avotra, A. A., Hussain, Z., Zonia, J. E., & Nawaz, A. 2022. Impact of green construction procurement on achieving sustainable economic growth influencing green logistic services management and innovation practices. *Frontiers in Environmental Science* 9. https://doi.org/10.3389/fenvs.2021.815928

Shaharudin, M. S., Ganesan, Y., Fernando, Y., & Haron, H. 2022. Green technology adoption in Malaysia: Where are we now? What Is lacking? & What should we do next? *Journal of Information System and Technology Management* 7(27): 109–121. https://doi.org/10.35631/jistm.727009

Shahi, S., Esnaashary Esfahani, M., Bachmann, C., & Haas, C. 2020. A definition framework for building adaptation projects. *Sustainable Cities and Society* 63. https://doi.org/10.1016/j.scs.2020.102345

Sharma, S. K., Mohapatra, S., Sharma, R. C., Alturjman, S., Altrjman, C., Mostarda, L., & Stephan, T. 2022. Retrofitting existing buildings to improve energy performance. *Sustainability* (Switzerland): 14(2). https://doi.org/10.3390/su14020666

Singhal, T. S., Jain, J. K., Ramacharyulu, D. A., Jain, A., Abdul-Zahra, D. S., Manjunatha, & Srivastava, A. P. 2024. Eco-design of products and processes: A review on principles and tools for sustainable manufacturing. E3S Web of Conferences, 505. https://doi.org/10.1051/e3sconf/202450501033

Soto, T., Escrig, T., Serrano-Lanzarote, B., & Desantes, N. M. 2020. An approach to environmental criteria in public procurement for the renovation of buildings in Spain. *Sustainability* (Switzerland): 12(18). https://doi.org/10.3390/su12187590

Taghizadeh-Hesary, F., & Yoshino, N. 2020. Sustainable solutions for green financing and investment in renewable energy projects. *Energies* 13(4). https://doi.org/10.3390/en13040788

Tawfik Alqadami, A., Abdullah Zawawi, N. A. W., Rahmawati, Y., Alaloul, W., & Alshalif, A. F. 2020. Challenges of Implementing Green Procurement in Public Construction Projects in Malaysia. *IOP Conference Series: Earth and Environmental Science* 498(1). https://doi.org/10.1088/1755-1315/498/1/012097

Trofimova, P., Cheshmehzangi, A., Deng, W., & Hancock, C. 2021. Post-occupancy evaluation of indoor air quality and thermal performance in a zero-carbon building. *Sustainability* (Switzerland): 13(2): 1–21. https://doi.org/10.3390/su13020667

Vejaratnam, N., Mohamad, Z. F., & Chenayah, S. 2020. A systematic review of barriers impeding the implementation of government green procurement. *Journal of Public Procurement* 20(4): 451–471.

Weerasinghe, L. N. K., Darko, A., Chan, A. P. C., Blay, K. B., & Edwards, D. J. 2024. Measures, benefits, and challenges to retrofitting existing buildings to net zero carbon: A comprehensive review. *Journal of Building Engineering* 94. https://doi.org/10.1016/j.jobe.2024.109998

Wilson, I. E., & Rezgui, Y. 2013. Barriers to construction industry stakeholders' engagement with sustainability: Toward a shared knowledge experience. *Technological and Economic Development of Economy* 19(2): 289–309. https://doi.org/10.3846/20294913.2013.799105

Xie, Y., & Liu, Y. 2022. Tripartite evolutionary game analysis of stakeholder decision-making behavior in energy-efficient retrofitting of office buildings. *Sustainability* (Switzerland): 14(18). https://doi.org/10.3390/su141811697