EXPLORING GREEN PROCUREMENT TO DRIVE SUSTAINABLE PERFORMANCE FOR MALAYSIAN CONSTRUCTION INDUSTRY

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying

Lee Kong Chian Faculty of Engineering and Science
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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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ABSTRACT

Achieving sustainable excellence in the Malaysian construction industry requires shifting from conventional procurement practices that contribute to environmental degradation. Despite growing sustainability awareness, green procurement adoption remains constrained by industry challenges. This study aims to investigate green procurement in Malaysian construction projects by identifying prevalent practices and examining key drivers influencing adoption. A quantitative approach is employed using a structured questionnaire, with 140 responses gathered from developers, consultants and contractors in the Klang Valley. The findings demonstrate that primary green procurement practices currently adopted are e-procurement, procuring non-toxic and low-volatile organic compounds (VOCs) materials, waste management and recycling, purchasing green products and services and giving preference to certified products. Key drivers include environmental sustainability, implementation of incentive policies, regulations and standards of green procurement, availability of green suppliers and innovation and technology. Spearman Correlation Test revealed a significant relationship between “Qualification of stakeholders based on knowledge and experience” and “Improving community health and quality of life” while factor analysis uncovered 4 underlying factors, namely institutional and strategic support, market and business competitiveness, availability of green resources and infrastructure and stakeholder engagement and social responsibility. These findings support the development of strategic policies and best practices to enhance green procurement. This study provides evidence-based recommendations for policymakers and industry stakeholders to integrate green procurement into standard construction practices. The originality of this study lies in quantifying key determinants of green procurement adoption in Malaysia, bridging the gap between theoretical discussions and practical applications in sustainable construction.

Keywords: green procurement; sustainable excellence; environmental sustainability; construction industry; procurement strategies

Subject Area: TA190-194 Management of engineering works

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LIST OF SYMBOLS / ABBREVIATIONS

α	Cronbach's alpha value
r_s	Strength of relationship between variables
δ	Standard deviation
AI	Artificial Intelligence
Asymp. Sig	Asymptotic Significance
ASEAN	Association of Southeast Asian Nations
BIM	Building Information Modeling
BREEAM	Building Research Establishment Environmental Assessment Methodology
BQ	Bills of Quantities
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CCC	Construction Consolidation Centres
CDW	Construction and Demolition Waste
CIDB	Construction Industry Development Board
CITP	Construction Industry Transformation Program
CLT	Central Limit Theorem
CO_2	Carbon Dioxide
CSR	Corporate Social Responsibility
EC	Environmental Capabilities
EFA	Exploratory Factor Analysis
EI	Eco-Innovative
EIA	Environmental Impact Assessment
ESG	Environmental, Social and Governance
EVCS	Electric Vehicle Charging Stations
GBI	Green Building Index
GDP	Gross Domestic Product
GFA	Gross Floor Area
GGP	Government Green Procurement
GHG	Greenhouse gases
GMFC	Green Mineral Fibre Cement

GPP	Green Product Procurement
GSCM	Green Supply Chain Management
G-SEED	Green Standard for Energy and Environmental Design
GTI	Green Technology Innovation
GTIB	Green Technology Innovation Behaviour
GTMP	Green Technology Master Plan
GVC	Governmental Venture Capital
HKGLS	Hong Kong Green Label Scheme
IR	Industrial Revolution
IS	Information Sharing
ISO	International Standards Office
IBS	Industrialised Building Systems
IT	Information Technology
JIT	Just-In-Time
JV	Joint Ventures
KMO	Kaiser–Meyer–Olkin
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
MFC	Mineral Fibre Cement
MNCs	Multinational corporations
PE	Power Electronics
PPPs	Public-Private Partnerships
PV	Photovoltaic
R&D	Research and Development
RMK-12	12th Malaysian Plan
SMEs	Medium-Sized Construction Firms
SCP	Sustainable Consumption and Production
SD	Standard Deviation
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Sciences
UK	United Kingdom
US	United States
UTAR	Universiti Tunku Abdul Rahman
UV	Ultraviolet

VOCs	Volatile Organic Compounds

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CHAPTER 1

INTRODUCTION

1.1 Background

According to Alaloul, et al. (2021), construction industry acts as a significant driver of economic growth and development all over the world and eventually contributes significantly to gross domestic product (GDP). Pervez, Ali and Petrillo (2021) highlight that the construction industry contributes approximately 13% of global GDP and this percentage is expected to rise quickly to 14.7% by 2030. Referring to Figure 1.1, despite the slower global economic growth in 2023, which caused GDP in Malaysia to decline from 8.9% in 2022 to 3.6% in 2023, the construction sector contributed 3.6% of the country's GDP in 2023 and grew at 6.1%, a rate that was 1% faster than in 2022. Ranjetha, et al. (2022) and Khaderi, et al. (2022) underscore that the construction industry also possesses strong linkages to other industry sectors such as manufacturing and financial industry since it is a combination of various economic sectors. The industry offers employment opportunities to people with a variety of expertise as numerous specialists, materials and equipment are required to enhance the performance of a construction project. Thus, it is undoubtedly that the construction industry contributes significantly to the growth of the national economy.

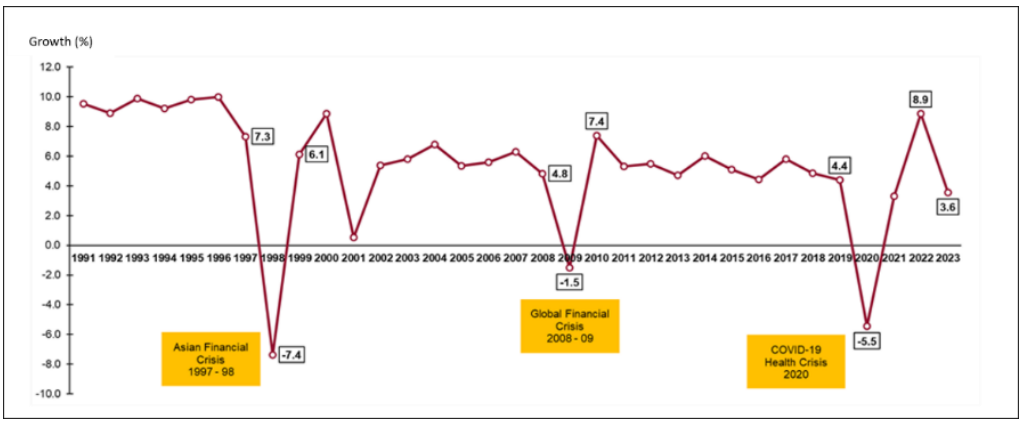

Figure 1.1: Annual Percentage Change of GDP In Malaysia, 1991-2023.

Source: Department of Statistics Malaysia (DOSM), 2024

Although the construction industry is vital to economic growth, there are severe environmental issues associated with it. In many developing nations, rapid physical development is undertaken in order to meet the growing demands of the population. However, this rapid expansion also frequently results in pollution, higher emissions of carbon dioxide (CO_2) and the disturbance of ecosystems, all of which exacerbate climate change and ozone depletion. The root causes of these issues are the excessive reliance on natural resources and high energy consumption of the construction industry (Bohari et al., 2017; Alqadami et al., 2020b). In addition, substantial demand for energy and natural resources has caused the global utilisation of non-metallic minerals to rise from 34.3% to 40%. The demand for materials will reach 183 billion tonnes per year by 2050 if current patterns in production and consumption remain (Opoku et al., 2022). These facts underscore the urgent global concerns associated with the construction industry, such as resource scarcity and climate change.

Sustainable development was introduced to address significant environmental challenges by emphasising resource and energy conservation, material recycling, lowering toxic emissions and enhancing indoor living conditions while preserving the capacity of the ecosystem (Alqadami et al., 2020a). Sustainable construction is later included in the sustainable development concept, which aims to harmonise and balance the economy, society and environment. Various factors, such as customer expectations, tighter government regulations, growing public awareness and concerns as well as social engagement further drive the adoption of sustainable construction. For instance, the Singaporean government has implemented incentives that benefit construction companies to encourage sustainable practices while the National Design Standard for Energy Efficiency and an Evaluation Standard of Green Building have been released by the Chinese government to encourage the construction of green buildings. Similarly, the public and construction stakeholders in Ghana, Cambodia and Vietnam have recently shown a great deal of interest in certified green building projects (Van Nguyen, 2023).

In the meantime, the United Nations developed Sustainable Development Goals (SDGs) to provide a worldwide framework for attaining sustainable development by 2030 in terms of the environmental, social and economic domains. 27% of the SDGs are indirectly related to construction

operations while 17% of the targets directly address various aspects of sustainability. For instance, SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) are prevalent to achieve by the construction industry. In order to facilitate the achievement of SDG 12, green procurement practices were implemented in the industry (Fei et al., 2021; Opoku et al., 2022). Applying green procurement can improve the reputation of a nation while also effectively addressing environmental degradation issues. However, there is currently limited research on green procurement in the Malaysian construction industry. Therefore, this study is necessary to discover the existing green procurement practices and their drivers to improve public awareness of the significance of green procurement and the necessity of implementing such practices.

1.2 Problem Statement

According to a study conducted by Crawford (2022), 36.0% of global energy consumption and 39.0% of greenhouse gas (GHG) emissions are attributed to the construction and utilisation of buildings and infrastructure. The increased air conditioning consumption and demand for resources, along with global population growth and growing living standards, would further exert pressure on GHG emissions. This Australian study also observes that the top five countries in terms of greenhouse gas emissions are China, India, South Africa, Taiwan and South Korea. China and India contributed 2.05 kgCO_2e/Euro and 1.74 kgCO_2e/Euro to the GHG emissions, respectively, with the production of cement, lime and plaster accounting for the majority of the emissions at 29.1% and 17.9%, respectively. In addition, a study in Malaysia conducted by Musarat, et al. (2021) highlights that the construction industry significantly contributes to CO_2 emissions when construction activities increase. This could be attributed to the burning of cement, the production of steel and other building components, as well as the operation of plant and machinery. Furthermore, variations in construction methods also result in varying levels of GHG emissions. The majority of developing nations, such as Pakistan, adopt conventional construction methods to construct buildings, leading to substantial waste generation and carbon dioxide emissions (Pervez, Ali and Petrillo, 2021).

Bohari et al. (2017) underscore that the environmental footprint of a project is mostly influenced by critical decisions made in the early phases of the project and one of the biggest and most effective change agents is said to be procurement. Procurement is the manner of purchasing products and services for a construction project and green procurement is being implemented in the industry to promote sustainable and green construction by reducing greenhouse gas emissions and pollution levels (Yap et al., 2024b). These procurement practices differ from conventional construction procurement practices, which primarily prioritise the principle of selecting the lowest bidder, regardless of the implications of construction activities on the surrounding community and environment. On the other hand, green procurement seeks to avoid environmental damage while also benefiting project stakeholders socially and economically. Hence, project stakeholders are able to achieve design and development requirements while obtaining value of money for the project (Opoku et al., 2022).

Furthermore, green procurement incorporates environmental concerns into procurement approaches, policies and procedures (Yap et al., 2024b). Asian nations such as Japan, South Korea, China, the Philippines and Thailand have adopted several regulations on Green Product Procurement (GPP) to encourage the purchase of products and services that are less harmful to the environment during the project lifecycle (Mungkung et al., 2021). In Malaysia, the MyHijau Programme, which was established in 2012, is one of the programmes which implements green procurement as a management strategy for environmental issues (Bohari et al., 2017). This initiative is further supported by its integration into major national policies, including the 11th Malaysia Plan (2016–2020), the Construction Industry Transformation Programme (CITP) 2016–2020, and the National Construction Policy 2030 (NCP2030) (Anuar, Khalil and Bohari, 2021). Studies conducted by Buniamin et al. (2016) and Razali et al. (2021) further emphasise the essential nature of considering environmental characteristics during the pre-construction, construction and post-construction stages. However, these studies highlight that green procurement is not yet widely adopted in Malaysia as conventional procurement techniques continue to prevail in the Malaysian construction industry.

The low implementation of green procurement practices in Malaysia may be attributed to a lack of awareness about its potential to deliver environmentally friendly projects. Furthermore, contractors frequently encounter challenges while attempting to enhance environmental performance in construction projects. Construction companies also struggle to adopt green procurement practices due to inadequate government regulations, weak enforcement mechanisms and insufficient promotional efforts in the country (Hadi, Shafiei and Ismail, 2022). Nevertheless, it is known that the client's needs and wants should be taken into consideration while determining the procurement options throughout the early stages of development. The choices made at this stage can act as strong catalysts for incorporating green practices throughout the entire construction period (Razali et al., 2021).

Concomitantly, numerous international studies have been conducted with an emphasis on green procurement in the construction industry. For instance, Opoku, et al. (2022) investigate the factors that encourage and hinder the use of sustainable procurement in the Chinese construction sector and its impact on achieving SDG 12. Similarly, Mungkung, et al. (2021) examine the context, policy and practice of GPP in Thailand to assess the progress towards Sustainable Consumption and Production (SCP) of the country. Moreover, a study conducted by Razali, et al. (2021) not only highlights the readiness of the Malaysian construction sector for green procurement but also outlines the obstacles and key factors of the adoption. In contrast, Khaderi, et al. (2022) focus on assessing the challenges to implementing green procurement from the developer's perspective while Yap et al. (2024b) explore the advantages of implementing green procurement strategies in the contexts of the environment, economy and society.

Based on the aforementioned studies, the findings by Opoku, et al. (2022) may not be applicable to all developing nations as the respondents are primarily from developed regions in China. Moreover, although green procurement has been extensively studied in Malaysia, the majority of these studies have concentrated on the benefits and barriers of green procurement, leaving limited studies on the exploration of actual green procurement practices in the nation's construction sector. Furthermore, the study carried out by Razali, et al. (2021) concentrates solely on the perspectives of consultants in Kuala

Lumpur and Selangor, which may not be representative of the entire construction sector in Malaysia. Similarly, the study conducted by Bidin et al. (2020) relies on literature reviews and focus group discussions with individuals experienced in green projects, thus, the results may not offer broadly applicable insights due to the limited number of participants and lack of quantitative data necessary for robust statistical analysis. These existing studies often focus on the theoretical benefits of green procurement rather than examining its real-world application, leaving industry stakeholders with limited insights into effective strategies for implementation. In order to bridge the knowledge gap, this study first assesses the current green procurement practices within the Malaysian construction industry. Once a clear understanding of these practices is established, the study then identifies the key drivers influencing their adoption. By doing so, this study aims to provide actionable insights that support the development of targeted strategies to enhance green procurement adoption and improve the industry's overall sustainability performance.

1.3 Research Aim

The study aims to thoroughly investigate green procurement practices in the Malaysian construction industry and discover the enablers that promote a more sustainable and environmentally friendly construction environment.

1.4 Research Objectives

To accomplish the aforementioned research aim, three research objectives have been developed:

(i) To identify green procurement practices in the Malaysian construction industry.

(ii) To examine the drivers for green procurement practices in the construction industry.

(iii) To uncover the underlying factors for green procurement practices in the construction industry.

1.5 Research Methodology

This study adopted a quantitative approach in order to accomplish the aim of the study. A Google Forms survey was developed to assess the opinions of

clients, consultants and contractors regarding the various practices and drivers of green procurement in the Malaysian construction industry. The survey was sent to the respondents through emails and social media platforms, including LinkedIn, WhatsApp, as well as Instagram. After that, the questionnaire survey was analysed using Shapiro-Wilk Test, Cronbach's Alpha Reliability Test, Mean Score and Standard Deviation, Kruskal-Wallis H Test, Spearman's Correlation Test as well as Factor Analysis. Figure 1.2 illustrates the research plan of this study.

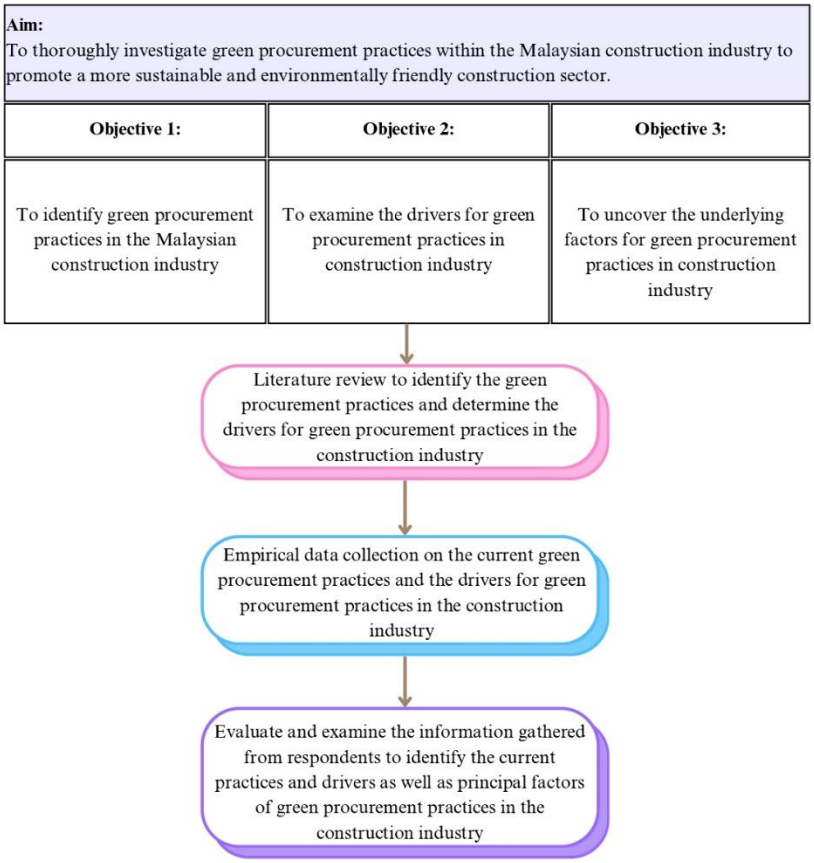

Figure 1.2: Research Plan.

1.6 Research Scope

This study examines the perspectives of construction professionals regarding the present green procurement practices adopted in Malaysian construction projects. It tends to discover the drivers and underlying factors for the implementation of green procurement practices in the construction industry. The scope encompasses a broad spectrum of project types, including residential,

commercial, industrial and infrastructure developments, in both the public and private sectors. The study focuses on construction professionals in the Klang Valley, Malaysia, with the targeted respondents including clients, consultants and contractors participating in the procurement process.

1.7 Outline of the Report

This study is systematically presented in five chapters to ensure clarity and coherence. The following shows the structure of this report:

Chapter 1: Introduction

This chapter outlines the overall content of the study, providing readers with an overview of the research study completed. It discusses the implications of the construction industry on both the global and national economies. Furthermore, the problem statement, research aim and objectives, research methodology, scope of the study as well as chapter outline are all clearly defined. This chapter also provided readers with a better understanding of the purpose of the research study in addition to revealing the existence of problems in the construction industry.

Chapter 2: Literature Review

Firstly, the fundamental concept of green procurement is explained in Chapter 2. Subsequently, a literature review was conducted by analysing, evaluating and synthesising previous studies on the topic of green procurement. By reviewing and comparing the findings of various researchers' works, the current green procurement practices and their drivers in construction projects are presented.

Chapter 3: Research Methodology

This chapter outlines the research design and methodological framework employed in this study. A quantitative method approach was adopted throughout the entire study. The development and distribution of structured questionnaires to targeted respondents were vital in order to obtain the relevant information. This chapter also discussed the types of research, research methodology, procedural steps, sampling design, data collection strategies and data analysis approaches.

Chapter 4: Result and Discussions

In Chapter 4, the data gathered from the questionnaire was analysed and recognised and the outcome of the subsequent analysis in relation to that interpretation was discussed. To achieve the research aim, this chapter focuses on analysing the data gathered from respondents to better understand the research aims and achieve the research objectives.

Chapter 5: Conclusion and Recommendation

Chapter 5 summarises the main findings and highlights the important contents discussed in the previous chapter. The chapter also details the practical and theoretical contributions of the study, highlights existing limitations, and puts forward several recommendations aimed at guiding future investigations in the domain of sustainable construction procurement.

1.8 Summary

A research gap has been effectively discovered after the background of the study has been analysed. This underscores the necessity for a study that evaluates green procurement practices and principal factors of green procurement practices to promote sustainability within the construction industry. Hence, the study’s aims and objectives have been developed to bridge the knowledge gap and enhance green procurement. This study primarily aims to raise industry stakeholders' consciousness regarding green procurement practices in order to improve environmental performance and lessen the ecological impact of construction activities.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter critically reviews existing literature and scholarly publications related to green procurement practices. Firstly, this chapter begins with a succinct comparison between conventional procurement and green procurement in the construction industry to facilitate a clearer understanding of their distinctions. An in-depth review of relevant literature on green procurement practices is undertaken to establish a solid foundation for the study. Furthermore, this chapter covers the possible drivers that enhance green procurement adoption in the construction industry.

2.2 Procurement in Construction Industry

According to Kumaraswamy and Dissanayaka, (1998, p.225), procurement is "*the action or process of acquiring or obtaining material, property or services at the operational level*". On the contrary, "*the framework within which construction is brought about, acquired or obtained*" is the definition of construction procurement. Thus, procurement in the construction industry can refer to the systematic process of acquiring the necessary materials or services in accordance with the contract to carry out the construction projects.

Saferi et al. (2018) highlight that procurement in the construction industry acts as a vital connection between the supply and demand of a project, ensuring that all necessary activities and resources are acquired in order to fulfil project objectives. For instance, engineers, architects, contractors, surveyors, suppliers and labourers collaborate in order to satisfy their clients' requirements. Furthermore, the success of a project is mostly determined by selecting the best procurement approach, which is dependent on the willingness and capabilities of the construction stakeholders. However, procurement is also a unique and complicated process that includes careful management at every step of project development (Bohari et al., 2020). Grandia and Meehan (2017) emphasise that procurement in construction also entails strategic choices that are made to guarantee the prudent allocation of resources and adherence to regulatory

requirements. In particular, public procurement has to provide value to the public by ensuring that public funds are used prudently and that contractors are able to successfully supply the required goods and services.

2.3 Green Procurement in Construction Industry

The term "green" in the construction industry refers to the integration, acknowledgement and implementation of environmental practices during the planning phase in order to minimise the environmental impacts of construction activities as well as ensure sustainability throughout the project lifecycle (Bidin et al., 2018). According to Bohari et al. (2017, p.692), green procurement is defined as "*the act of obtaining or disposal and recognition of goods, services, engineering and construction work. It also encompasses the integration and implementation of environmentally friendly practices throughout the processes involved in producing a construction output such as a building or infrastructure*". Therefore, acquiring products and adopting green practices in compliance with rules, regulations, and guidelines, with the aim of minimising adverse environmental effects, is considered green procurement in the construction industry (Saferi et al., 2018; Alqadami et al., 2020b). Furthermore, green procurement considers the entire project lifecycle, from extraction of raw materials, transportation, production, packaging, storage and usage to disposal or recycling. By prioritising green procurement, the construction industry can attain several benefits including reduced energy consumption, lower waste production and reduced carbon footprints (Wong, Chan and Wadu, 2016).

2.4 Green Procurement Practices

Green procurement practices refer to an extensive variety of strategies intended to lessen the impact of construction projects on the environment. Therefore, this study will discuss several examples of green procurement practices adopted in the construction industry, emphasising both conventional and innovative green procurement approaches that support environmental sustainability.

2.4.1 Conventional Green Procurement Practices

2.4.1.1 Qualification of Stakeholders Based on Knowledge and Experience

In the construction industry, the qualification of stakeholders based on their knowledge and experience significantly impacts the green performance of projects. The effective implementation of green procurement can be severely hampered by a lack of knowledge and pertinent information on environmental concerns. Therefore, it is imperative to have access to green expertise and specialised resources to facilitate green procurement and decision-making process (Khahro et al., 2021; Yap et al., 2024a). For instance, stakeholders are more willing to adopt green building technologies in construction projects if they are conscious of the associated costs and benefits (Chan, Darko and Ameyaw, 2017). Additionally, Bohari et al. (2017) emphasise that main contractors with extensive expertise and experience are better equipped to oversee green projects. However, in situations where the main contractors are inexperienced, experienced project managers and green consultants in the construction team are engaged to ensure compliance with green building guidelines and standards.

A study conducted in Turkey further explores the significance of contractor prequalification. Prequalification ensures that only qualified contractors are selected for the construction projects, lowering the risks involved in engaging inexperienced contractors. This study also indicates that a contractor's ability to provide lower life cycle costs while also satisfying the sustainability requirements of the client is a crucial factor that needs to be taken into account. Therefore, the prequalification stage may serve as a filter to guarantee that contracts are only given to contractors who possess sustainability competency (Gurgun and Koc, 2020).

2.4.1.2 Opting For Products with Minimal or Eco-Friendly Packaging

Opting for products with minimal or eco-friendly packaging is recognised as a crucial green procurement practice within the construction industry. A study conducted in Czechia highlights that approximately 34% of construction waste on sites is made up of packaging materials. This study also emphasises the significance of reducing material packaging and choosing materials that facilitate recovery scenarios rather than ones that end up in landfills or

incineration. This approach reduces pollutants and minimises the environmental effects of construction materials while also preserving natural resources (Pesta, Seresova and Koci, 2020).

According to Gulsun and Mic (2020), excessive packaging can result in unnecessary resource consumption while inadequate packaging might cause product damage and spoilage. Therefore, appropriately sized and durable packaging is necessary to reduce waste and enhance natural resource efficiency. Moreover, incorporating recyclable and green materials into packaging not only complies with regulatory standards but also significantly lowers the carbon footprint throughout the supply chain.

Similarly, a study conducted in Kenya also emphasises the effects of packaging decisions on the economy and environment. The results of the study show that despite using non-biodegradable and non-recyclable materials, adopting green packaging is positively associated with improved performance for manufacturing firms. This involves utilising recyclable materials and optimising packaging techniques to reduce costs and increase consumer satisfaction (Gikonyo, Ngugi and Paul, 2022). Hence, these studies have underscored the critical role of eco-friendly packaging practices in green procurement practices within the construction industry.

2.4.1.3 Procuring Non-Toxic and Low-VOC Materials

Formaldehyde and benzene are two examples of volatile organic compounds (VOCs) that are categorised as human carcinogens (Kwon, Ahn and Kang, 2021). Construction materials such as laminate flooring, hardwood, plywood, adhesives, paints, varnishes and different coatings applied to walls, ceilings and floors are common indoor sources of these VOCs. Furthermore, additional negative effects on indoor air quality will result if these VOCs react with ozone (Cheng, Lin and Hsu, 2015; Kozicki et al., 2018; David and Niculescu, 2021).

To mitigate these negative effects and enhance indoor air quality, non-toxic or low-VOC materials should be used in construction. Innovative approaches, including switching to mineral rather than acrylic binder paints, can drastically lower VOC emissions. A study in France has shown that utilising mineral binders instead of acrylic binders significantly lowers overall VOC emissions by 43% and formaldehyde emissions by 66% (Morin et al., 2019).

Furthermore, a study conducted in Taiwan further highlights the benefits of using mineral-based construction materials such as green mineral fibre cement (GMFC) and mineral fibre cement (MFC), enhancing the appeal of these materials as safer and more sustainable options for construction (Cheng, Lin and Hsu, 2015).

2.4.1.4 Giving Preference to Certified Products

Since green product certification is carried out by a third party, the certification has a substantial impact on impartiality and dependability. In the construction industry, certifications from organisations such as Green Earth, Leadership in Energy and Environmental Design (LEED) and the National Green Building Standards are commonly recognised. These certificates are extremely beneficial in promoting environmentally friendly practices and lowering greenhouse gas emissions, particularly in developing countries such as Malaysia as establishing these certifications is an efficient and affordable process (Yousif, Misnan and Ismail, 2023).

Opoku and Fortune (2014) underscore that construction firms can guarantee the environmental friendliness of the materials used in the projects by adhering to the certification requirements established by the appropriate certifying agencies. Choosing materials with eco-certifications, such as eco-label products, improves indoor air quality and fosters a better interior environment during manufacturing and consumption (Yuan, 2023). An eco-label is known as "*a label which identifies overall environmental preference of a product or service within a specific product/service category based on life cycle considerations*" (Bratt et al., 2011, p.1632).

Additionally, eco-labelling improves the sustainable performance of building projects by raising stakeholder understanding and accelerating the selection of environmentally favourable products. This is due to the fact that these labels detail the manufacturers' approach to addressing the environmental impact of the products, providing recommendations to construction stakeholders in order to select the most appropriate green products and services (Yousif, Misnan and Ismail, 2023). According to Mungkung et al. (2021) and Yuan (2023), purchasing products and services with an eco-label has the potential to reduce greenhouse gas emissions and other environmental effects.

Since the majority of sustainable building materials are frequently certified, these materials can contribute to the development of cleaner and safer construction. Moreover, the certified sustainable materials also improve occupant health (Yousif, Misnan and Ismail, 2023). As Thailand has a well-developed plan for sustainable consumption and production, other Association of Southeast Asian Nations (ASEAN) countries are able to gain benefit from the practical experience with eco-labelling (Mungkung et al., 2021).

2.4.1.5 Adoption of Local Suppliers

According to Balasubramanian (2020), purchasing from local suppliers is considered a green practice in the construction industry. When compared to international suppliers who require greater transport distances, this approach reduces the transportation-related carbon footprint with a potential reduction of approximately 6 to 8%. Similarly, McMurray et al. (2014) observe that Malaysian organisations prioritise acquiring from small and local suppliers, underscoring the significance of this practice. However, a study by Opoku et al. (2022) reveal that the adoption of local suppliers and contractors is often undervalued when it comes to green procurement practices.

Purchasing locally can shorten lead times and reduce waste in supply chains. According to Dadhich et al. (2015), reducing the total distance of transportation contributes to positive environmental effects since less fuel is required, hence, fewer pollutants are contributed and strain on the road would be lessened. A study in Luxembourg highlights that Construction Consolidation Centres (CCC), which are usually located near urban areas, gather materials from nearby suppliers to minimise the distance and number of trips required for material delivery. By reducing the number of transports on the road, carbon dioxide emissions have decreased from 245 tonnes to 190 tonnes annually and nitrogen oxide emissions from 2300 kg to 1500 kg (Guerlain, Renault and Ferrero, 2019).

2.4.1.6 Purchasing Green Products and Services

Construction industry is a significant user of raw materials, which account for 30% to 40% of the total cost of a project (Zuo et al., 2012; Guerlain, Renault

and Ferrero, 2019). In this case, the production of concrete emits one of the largest amounts of carbon dioxide, exacerbating climate change (Yuan, 2023).

In light of these issues, advances in materials, approaches and contractors' knowledge of carbon emissions reduction are critical to achieving a carbon-neutral construction project (Zuo et al., 2012). To ensure that construction projects are sustainable, Bohari et al. (2017) recommend a strict procedure should be followed to verify the suppliers' environmental credentials, such as requiring the suppliers to submit green certificates to guarantee all of the products comply with green standards. Furthermore, selecting materials that comply with the Green Building Index (GBI) is preferable to ensure that the materials used in construction projects are sustainable and environmentally friendly.

Sustainable materials such as bamboo and straw boards also provide promising alternatives. These materials consume less energy and have a minimal environmental impact (Yuan, 2023). In China, greener alternatives are progressively taking the place of traditional construction materials including concrete, steel, wood and stone. Bamboo, in particular, stands out due to its carbon sequestration abilities, which significantly lower carbon emissions (Lee et al., 2021).

In addition, a study in Sweden highlights innovative products such as bio-green panels can improve energy efficiency, promote recycling as well as generate renewable energy sources. These panels have improved the quality of air, decreased the consumption of energy and enhanced the aesthetic of the building since vegetation is integrated into the building exteriors. These panels help reduce the influence of the urban heat island effect and the carbon footprint by replacing reinforced concrete walls with sustainable materials such as bamboo and recycled plastic (Almusaed et al., 2023). Furthermore, a study in Canada reveals that green panels installed on rooftops can lead to a 66% yearly reduction in energy consumption, with daily savings of over 85% in the spring and summer and approximately 44% in the autumn and winter (Mahmoodzadeh et al., 2020). Additionally, a study in Hong Kong underscores that energy savings ranging from 40% to 110% can be achieved by switching to green roofs from white roofs (Li and Yeung, 2014).

Moreover, Saeli et al. (2023) discover that reusing organic household residue in part replacement of sand to produce green bio-composite mortars can reduce environmental footprint, including methane and carbon dioxide emissions, fewer natural resources are used and residues are not directly released into the environment.

2.4.1.7 Incorporation of Green Specifications into The Contract

Green building specifications comprise guidelines, codes and standards that prioritise environmental friendliness and sustainable development to ensure that construction projects adhere to sustainable practices. Including these specifications in contracts can result in significant social, economic and environmental benefits. A study conducted in China emphasises that the lack of sufficient government backing is the primary obstacle to adopting these standards in the country. This study also reveals that government action is mostly required to overcome every barrier listed in the findings (Wang, Zhang and Pasquire, 2018).

In contrast, Bohari et al. (2017) underscore that the green criteria have been successfully incorporated into tenders and contracts by the Malaysian construction industry. To ensure these green criteria are met, the contractual requirements of a traditional building contract would include the choice of material, chemical composition and functional features of the products. In this situation, the designers play a vital role since careful consideration is required to recommend materials that are sustainable and derived from sustainable resources. Prioritisation would be given to building materials with the lowest resource inputs, waste and emissions into the environment. The designers would also take potential reuse and recycling alternatives into consideration (Opoku and Fortune, 2014; Athigakunagorn et al., 2024).

2.4.1.8 Purchase Value of Money

Concerns about the purchasing value of money arise during the pre-qualification of suppliers and contractors. Sustainability factors are incorporated into the tender evaluation instead of concentrating only on the lowest bid price. This further emphasises the commitment to achieving environmental responsibility and long-term value in each procurement decision (Khan, Tong and Phung,

2024). A study in Malaysia highlights that most clients or consultants prefer contractors and suppliers who fulfil the required environmental standards, even in situations where there is a minor increase in cost. This cost rise is commonly linked to market restraints and could result in an 8% cost increase (Bohari et al., 2017).

However, a study in Canada asserts that the Canadian tender evaluation process is primarily concerned with cost, prioritising low-bid procurement and initial cost as the main criterion instead of comparing social and environmental criteria as well as life cycle costs. This study also underscores that there is a lack of information and standardised methods for assessing sustainability criteria in the Canadian construction industry (Ruparathna and Hewage, 2015). Meanwhile, a study in China affirms that the Chinese construction industry is also heavily focused on bidding costs. The notable gap in the priority of sustainable practices is attributable to clients placing less emphasis on energy-saving measures and material selection (Yan, Ye and Jiang, 2015).

2.4.1.9 Adoption of Energy-Efficient Machinery and Equipment

The increasing mechanisation of modern construction projects emphasises the significance of the productivity and efficiency of construction machinery and equipment. Previously, productivity, capacity and cost were the major factors to be taken into account while purchasing machinery and equipment. However, in light of the necessity of sustainability, these requirements have evolved to give preference to energy efficiency and environmental preservation when making purchases. In addition, air pollution from diesel-powered machinery continues to be a significant issue, underscoring the urgent need for sustainable and energy-efficient equipment design (Waris et al., 2014; Nwaogbe et al., 2025).

A study conducted in China highlights that air pollution in Beijing is mostly caused by construction machinery such as loaders, excavators and forklifts, which are frequently utilised in construction projects. Due to their high-power output requirements and challenging operating conditions, these machines, which are usually powered by diesel engines, emit extensive amounts of harmful pollutants, such as VOCs and nitrogen oxides, thereby having a detrimental effect on environmental air quality (Xue et al., 2022). Therefore, innovations in hydraulics and power electronics (PE) have emerged to be

revolutionary in tackling this issue. For instance, the integration of electrohydraulic hybrid systems in earthmoving equipment illustrates the enhancement of energy efficiency by integrating hydraulic and electric systems to optimise energy use and minimise carbon dioxide emissions (Quan et al., 2021).

Moreover, Waris et al. (2014) conducted a comprehensive study evaluating green equipment selection criteria that closely correlated with sustainability objectives. These factors include life cycle costs, performance, system capabilities, operational convenience, environmental effect as well as social benefits. Despite these evaluations, the findings reveal that the Malaysian construction sector prioritises productivity, safety features, ownership cost, operational cost and equipment selection efficiency over sustainable criteria. This indicates that there is an imbalance in the industry's priorities, where sustainable standards are being recognised but frequently overridden by the emphasis on cost-effectiveness and productivity.

2.4.1.10 Waste Management and Recycling

According to Opoku et al. (2022), a significant amount of waste is generated from the construction industry in most of countries. For instance, the construction industry contributes 40% of waste generation in China and Brazil, 44% in the UK and Australia and 27% in Canada. The Construction and Demolition Waste (CDW) predominantly consists of concrete, ceramics, mortar, masonry and packaging such as paper, plastic and wood while timbers, bricks, steel and plastics are commonly generated as construction waste in Malaysia. Improper waste management, mistakes during construction and issues with material handling are the main factors of construction waste generation. Furthermore, landfilling, which is the most common way to dispose of the CDW, exacerbates environmental deterioration, particularly in cases where the amount of waste exceeds the landfill capacity. However, implementing effective waste management strategies can mitigate the negative environmental impacts and generate significant economic advantages (Jin et al., 2017; Sa'i, Hashim and Omar, 2019; Nwaogbe et al., 2025).

Waste management has been discovered to be the main driver of sustainable procurement practices in China (Opoku et al., 2022). Similarly,

waste management is found to be a sustainability practice in the United Kingdom (UK) construction industry which is mostly engaged. This is because the significance of waste management to the planning and execution stages of construction projects is well-known in the UK, hence, waste management plans are integrated into various construction projects in the country. Moreover, the systematic targeting and assessment of waste management initiatives also shows the industry's dedication to sustainability as the majority of construction organisations have set targets for each project and periodically evaluate the performance. Effective waste management not only lowers the volume of waste and the cost of disposal in landfills but also improves a company's reputation (Osmani, 2012; Opoku and Fortune, 2014).

Mohammed et al. (2020) highlights that effective waste management can mitigate environmental degradation by prioritising the reduction, reuse and recycling of materials and components. Minimisation techniques have been embraced as a crucial strategy for promoting sustainability and alleviating pressure on limited land resources in land-scarce nations such as Singapore. To minimise waste production, these strategies include optimising material usage, avoiding over-ordering as well as integrating early planning and design considerations. Similarly, material reuse is actively encouraged in Hong Kong, where recycled paving blocks and concrete aggregates are used in new construction projects to reduce dependency on landfills. In addition, recycling waste from construction projects not only assists in reducing waste but also produces environmentally friendly green resources. As an illustration, the use of ecological cement, which is produced from recyclable materials including steel slag and volcanic ash, has proved to perform better than traditional cement in terms of resource consumption and carbon emissions (Lee et al., 2021).

Furthermore, Ajayi and Oyedele (2018) highlight that supplier commitments can significantly reduce construction waste by implementing take-back schemes, providing flexibility in supplying lower quantities, supporting Just-In-Time (JIT) procurement systems and altering material specifications to meet project-unique requirements. Since the contractor will be placing orders based on the quantity specified in Bills of Quantities (BQ), appropriate material take-off is essential to prevent overordering and excessive waste generation. Waste-efficient procurement is further enhanced by

procedures such as minimising packaging, purchasing pre-assembled or pre-cut products and ensuring materials are sufficiently protected throughout delivery. Therefore, there has been a greater emphasis placed on the significance of waste management in green construction.

2.4.2 Innovative Green Procurement Practices

2.4.2.1 E-procurement

The worldwide information technology (IT) revolution has led to the adoption of e-procurement in the public sector by nearly every country. For instance, e-procurement is becoming more and more popular in Canadian construction companies (Ruparathna and Hewage, 2015). E-procurement, which includes contracting, sourcing, purchasing, auctioning and negotiating, is defined as the implementation of technology in the supply chain management phase (Singh and Chan, 2022). Compared to traditional procurement methods, e-procurement can save more time and cost while increasing efficiency and eliminating waste. E-catalogues, e-ordering, e-sourcing and e-tendering are some of the examples of the implications of e-procurement (Opoku et al., 2022). According to Wimalasena and Gunatilake (2018), the fundamental principle behind e-tendering is similar to the traditional method as the process is merely switching from paper-based to electronic approaches. Therefore, e-procurement drastically reduces the need for paper products and lowers the carbon footprint. Furthermore, a study conducted by Yu, Yevu and Nani (2020) presents a conceptual framework which can serve as a guide to improving the effectiveness of e-procurement integration with green procurement in construction projects. However, Opoku et al. (2022) highlight that the project stakeholders neglected the significance of altering the working methods as one of the sustainable practices in contrast to employing energy-efficient equipment in the project.

2.4.2.2 Prefabrication and Modular Construction

Prefabrication and modular construction help accomplish the objectives of green procurement through the reduction of environmental impacts, the advancement of resource efficiency and the enhancement of sustainability. Construction and demolition waste can be reduced by 52% when prefabrication is adopted in the construction project. This waste reduction is accomplished by

precise manufacturing techniques in controlled manufacturing environments where prefabricated components are produced on mechanised and standardised production lines rather than having wet trade on-site (Wu et al., 2021; Liu et al., 2022). Hence, this approach optimises resource utilisation and reduces material waste throughout the production stage.

Additionally, prefabrication greatly lowers greenhouse gas emissions and reduces dust production, both issues which are frequently encountered in traditional construction. In this situation, the main reason for the reduction is the decline in site activities that cause air pollution (Hu and Chong, 2021). A study by Tsoka et al. (2020) had evaluated the energy performance between conventional and prefabricated buildings, showing that prefabricated buildings have higher energy efficiency than the former. This improved efficiency is attributed to better insulation and energy-saving features since the components are produced in a controlled factory environment. However, prefabricated construction may necessitate heavy usage of power, which might adversely affect eutrophication and water intake.

A study by Wong and Loo (2022) further underscores the significance of prefabrication in enhancing workplace safety by reducing project accident rates and shortening construction durations, hence mitigating disruptions to surrounding populations. This is particularly relevant in densely populated urban areas such as Hong Kong where construction sites should be more productive due to the surrounding buildings and population. On the contrary, the application of prefabrication may be hindered by the requirement for greater on-site storage spaces and specialised logistic arrangements to prevent traffic disturbances as well as a reduction in design flexibility (Wuni et al., 2022).

2.4.2.3 Utilising Renewable Energy Sources or Technology

Achieving sustainability and carbon neutrality in construction requires a meticulous integration of renewable energy sources and technology. As this practice has the same objectives in minimising environmental impact, it is considered a green procurement practice. According to Khan and Al-Ghamdi (2021) and Chen et al. (2024), the adoption of solar panels and wind turbines can lessen the demand for fossil fuels which subsequently reduces greenhouse gas emissions. Since urban areas require more noise barriers to minimise noise

pollution and parking lots to accommodate the increasing number of vehicles, solar technology may also be utilised in constructing photovoltaic (PV) parking lot canopies and PV noise barriers (Vijayan et al., 2023). A notable study by Iringova and Kovacic (2021) has demonstrated the implementation of a PV system for a parking lot in Ilina. To maximise efficiency, the PV system was placed on a flat roof above the Electric Vehicle Charging Stations (EVCS). The system is able to supply sufficient electricity to operate six EVCSs and still satisfy the overall energy requirements of the building. Similarly, a study by Deymi-Dashtebayaz et al. (2022) in Russia investigated the performance of an integrated solar and wind energy system in a building. The finding indicates that the system could supply 99% of the electrical power and 61% of the annual heating demands. At the same time, the annual reduction in carbon dioxide emissions is 13,859 kg. Therefore, these studies outline the economic and environmental benefits of implementing renewable energy technologies into construction projects as well as emphasising the necessity of using clean energy sources as a fundamental green procurement practice.

2.4.2.4 Integration of Building Information Modeling (BIM) for Sustainability

Due to technological advancements, Building Information Modeling (BIM) has become indispensable in the construction industry and is an integral part of green procurement practices. BIM allows for the systematic management of project data and design in digital form throughout the project lifecycle. BIM also improves communication and decision-making in construction projects by including 3D models, enabling comprehensive environmental performance evaluations and the implementation of sustainability solutions (Wong and Zhou, 2015; Ferdosi et al., 2023).

During the design phase, the BIM system can extract the types and quantities of materials required for each element in the 3D model. Once the quantities of materials required for the construction activities are known, BIM can include information for construction waste estimation and planning, hence, the number of transportation delivery trips and the amounts of mandatory waste disposal charges can be predicted. In this case, BIM can also help create an efficient material recycling plan (Ajayi and Oyedele, 2018). Furthermore, BIM

aids in clash identification and design optimisation to further guarantee that projects are carried out with the fewest possible mistakes and waste (Al-Ashmori et al., 2020).

Apart from that, the application of BIM increases efficiency and productivity by integrating time and cost management which allows for real-time updates and monitoring throughout the project lifecycle (Al-Ashmori et al., 2020). For instance, BIM can be used in conjunction with Geographic Information System (GIS) technology to optimise the transportation routes of the concrete truck mixers and lower transportation-related carbon emissions during the construction phase (Wong and Zhou, 2015; Wang, Pan and Luo, 2019). Environmental benefits can also be realised by integrating BIM with prefabrication construction to reduce construction waste at the source (Wu et al., 2021).

2.4.2.5 Procuring Green Building Technologies

Green building technologies play a vital role in enhancing green performance within the construction industry. These technologies include an extensive variety of materials, methods as well as products intended to enhance urban environments, maximise resource utilisation and support cleaner production. These technologies not only save energy consumption in buildings but also improve individuals' physical and mental health (Yang et al., 2021). However, the effectiveness of these technologies is greatly enhanced when the features of natural resources and the climate of a country are taken into account. For instance, the technologies in Southeast Asia should be able to withstand the hot and humid tropical climate (Lai et al., 2023).

Water-saving technology, such as high-performance water-saving appliances and rainwater collection techniques, is frequently adopted in green buildings due to the global need to conserve freshwater. Pressurisation technology and intelligent control should be included in water-saving appliances such as faucets, toilets and showers to prevent excessive water use. The Singapore Art and Science Museum demonstrates a sustainable method for covering the water demand through the utilisation of rainwater. The spherical hole located in the centre of the museum roof gathers rainwater, which is subsequently filtered and used in various museum facilities (Lai et al., 2023).

Furthermore, the use of energy-efficient solutions, such as LED lighting, greatly reduces energy consumption in buildings by replacing fluorescent and incandescent bulbs (Lai et al., 2023). According to Siva, Hoppe and Jain (2017), energy-efficient lighting systems have a low payback period of less than three years. Thus, acquiring green building technology is an important green procurement practice since it not only addresses climate-related concerns but also encourages the use of water-saving and energy-efficient technologies, resulting in significant environmental and economic benefits.

Table 2.1: Literature Map for Green Procurement Practices.

Ref	Practices	No of Studies	Sources
	Conventional green procurement practices		
P1	Qualification of stakeholders based on knowledge and experience	5	Khahro et al. (2021), Yap et al. (2024a), Chan, Darko and Ameyaw (2017), Bohari et al. (2017), Gurgun and Koc (2020)
P2	Opting for products with minimal or eco-friendly packaging	3	Pesta, Seresova and Koci (2020), Gikonyo, Ngugi and Paul (2022), Gulsun and Mic (2020)
P3	Procuring non-toxic and low-volatile organic compounds (VOCs) materials	3	Kwon, Ahn and Kang (2021), Cheng, Lin and Hsu (2015), Kozicki et al. (2018), David and Niculescu (2021), Morin et al. (2019)
P4	Giving preference to certified products	5	Yousif, Misnan and Ismail (2023), Opoku and Fortune (2014), Yuan (2023), Bratt et al. (2011), Mungkung et al. (2021)
P5	Adoption of local suppliers	6	Balasubramanian (2020), McMurray et al. (2014), Dadhich et al. (2015), Guerlain, Renault and Ferrero (2019), Opoku et al. (2022)
P6	Purchasing green products and services	9	Zuo et al. (2012), Guerlain, Renault and Ferrero (2019), Yuan (2023), Bohari et al. (2017), Lee et al. (2021), Almusaed et al. (2023), Mahmoodzadeh et al. (2020), Li and Yeung (2014), Saeli et al. (2023)
P7	Incorporation of green specifications into the contract	3	Wang, Zhang and Pasquire (2018), Bohari et al. (2017), Opoku and Fortune (2014), Athigakunagorn et al. (2024)
P8	Purchase value of money	3	Khan, Tong and Phung (2024), Bohari et al. (2017), Ruparathna and Hewage (2015), Yan, Ye and Jiang (2015)
P9	Adoption of energy-efficient machinery and equipment	3	Waris et al. (2014), Nwaogbe et al. (2025), Xue et al. (2022), Quan et al. (2021)
P10	Waste management and recycling	7	Opoku et al. (2022), Sa'i, Hashim and Omar (2019), Jin et al. (2017), Nwaogbe et al. (2025), Osmani (2012), Opoku and Fortune (2014), Mohammed et al. (2020), Lee et al. (2021), Ajayi and Oyedele (2018)
	Innovative green procurement practices		
P11	E-procurement	5	Ruparathna and Hewage (2015), Singh and Chan (2022), Opoku et al. (2022), Wimalasena and Gunatilake (2018), Yu, Yevu and Nani (2020)
P12	Prefabrication and modular construction	5	Wu et al. (2021), Liu et al. (2022), Hu and Chong (2021), Tsoka et al. (2020), Wong and Loo (2022), Wuni et al. (2022)
P13	Utilising renewable energy sources or technology	4	Khan and Al-Ghamdi (2021), Chen et al. (2024), Vijayan et al. (2023), Iringova and Kovacic (2021), Deymi-Dashtebayaz et al. (2022)

P14	Integration of Building Information Modeling (BIM) for sustainability	4	Wong and Zhou (2015), Ferdosi et al. (2023), Ajayi and Oyedele (2018), Al-Ashmori et al. (2020), Wong and Zhou (2015), Wang, Pan and Luo (2019), Wu et al. (2021)
P15	Procuring green building technologies	3	Yang et al. (2021), Lai et al. (2023), Siva, Hoppe and Jain (2017)

2.5 Drivers of Green Procurement Practices

2.5.1 Policy and Governance Support

2.5.1.1 Availability of Policies and Guidelines

The government is crucial to the adoption of green procurement practices (Wong, Chan and Wadu, 2016). Government policies and guidelines can cultivate a way of thinking that will dedicate to the particular rules and regulations at the project level (Bidin et al., 2020). For instance, the Chinese government has enacted multiple mandatory policies to address pollution remediation. As a result, products that do not meet the prescribed standards are prohibited from entering the market and developers who use these materials would face heavy fines (Shen, Zhang and Zhang, 2017). Once these mandatory policies are established for all green products, services and practices, shortages of green materials can be addressed, thereby the construction industry may adopt comprehensive green procurement practices more easily (Razali et al., 2021).

According to Bidin et al. (2020), the establishment and implementation of these policies throughout the whole supply chain is also necessary for the practices to be effective. For instance, the government policy is implemented to encourage prefabrication adoption in the Hong Kong construction industry (Wong and Loo, 2022; Wuni et al., 2022). Nevertheless, Wong, Chan and Wadu (2016) present a different point of view, arguing that green procurement practices are becoming more common in Hong Kong's public sectors, but not in the private sectors. Similarly, the implementation of government green procurement (GGP) guidelines in Malaysia remains limited to government projects and does not provide comprehensive coverage of the entire project life cycle. Hence, these studies emphasise the necessity of comprehensive policies throughout the project life cycle (Razali et al., 2021).

Similar problems exist in Canada as well, where a lack of regulatory requirements frequently prevents the systematic implementation of sustainable procurement (Ruparathna and Hewage, 2015). Therefore, in order to overcome obstacles and guarantee the effective integration of green procurement throughout all construction stages, a proactive role in government to provide a strong and clear legislative framework is required.

2.5.1.2 Regulations And Standards of Green Procurement

Efficient standards are essential for improving the application of green procurement and advancing sustainability. These standards include evaluation criteria, green specifications and International Standards Office (ISO) certifications (Wong, Chan and Wadu, 2016; Nadeem, Mohamad and Nik Abdullah, 2017). The ISO 14000 series was developed by an independent organisation to offer a framework for enhancing environmental performance throughout the construction project operation (Zeng et al., 2003). According to Shurrab, Hussain and Khan (2019), the ISO certification may be included in the environmental criteria during the pre-qualification phase of the tendering process. For example, the clients may request the tenderers to submit the ISO 14001 certification since this certification is the most commonly accepted standard in the construction industry.

The lack of appropriate green standards and the scarcity of sustainable resources are the primary causes for the poor adoption of green practices in developing countries such as Nigeria and Ghana (Kineber, Kissi and Hamed, 2022; Eze, Sofolahan and Omoboye, 2023). This highlights the urgent need for governments and industry stakeholders to collaborate in developing updated standards to replace outdated green building codes and regulations (Ahmed et al., 2023). Furthermore, green material adoption has also been greatly accelerated by modifications to building codes and efficiency standards in the US construction industry. Therefore, strict environmental legislation is the driving force behind the transition from traditional to green procurement, forcing construction companies to prioritise sustainability and innovate in their material selection and construction practices (Shen, Zhang and Zhang, 2017).

2.5.1.3 Implementation of Incentive Policies

Government policy can play a significant role in promoting sustainable procurement since it incorporates both monetary and non-monetary incentives to encourage environmentally friendly procurement practices (Ruparathna and Hewage, 2015). For example, establishing incentives such as tax deductions or additional gross floor area (GFA) concessions can encourage construction firms to purchase green products even though these products are typically more expensive than traditional ones (Wong, Chan and Wadu, 2016; Razali et al.,

2021). Moreover, financial assistance such as discounts and subsidies provides further motivation for construction firms to integrate green concepts into the production of environmentally friendly and productive products (Bohari et al., 2017; Bidin et al., 2020; Razali et al., 2021). Furthermore, financial allowance can be awarded to developers if the project developments are certified as green buildings (Shen, Zhang and Zhang, 2017). Conversely, penalties such as taxes and additional charges should be imposed on parties that purchase environmentally unfriendly products and fail to comply with environmental standards (Nadeem, Mohamad and Nik Abdullah, 2017). Collectively, these researchers emphasise the necessity of integrating financial incentives and tax benefits throughout the construction process to successfully encourage the implementation of green procurement practices. According to Tong and Li (2018), offering subsidies occasionally produces greater results than regulatory pressure since the financial burden associated with research and development (R&D) expenses and the adoption of green technologies required to engage in green production is much lower.

2.5.1.4 Campaigns and Workshops

The effective adoption of green procurement practices in construction firms of each country is correlated with the awareness of and familiarity with policies, guidelines, regulations and standards. These frameworks are designed to serve as a guide for construction firms, however, compliance is limited if the construction stakeholders lack adequate awareness (Nadeem, Mohamad and Nik Abdullah, 2017). Increased efforts should be made by public and private organisations to offer additional campaigns and workshops that are able to disseminate this crucial knowledge and encourage industry-wide involvement (Razali et al., 2021). Through campaigns and workshops, construction stakeholders may acquire knowledge about ecological problems, the significance of the movement for sustainable development, government assistance, the positive impacts of acquiring green products as well as the drawbacks of high levels of pollution and carbon emissions in the environment (Masyhur et al., 2024).

Furthermore, according to Ikau and Joseph (2017) and Bidin et al. (2020), construction stakeholders are increasingly expected to fulfil societal

demands for environmental stewardship. Training modules organised by the Construction Industry Development Board (CIDB) Malaysia are an outstanding approach to ensure that stakeholders are well-versed in the relevant regulations and standards in order to facilitate their adherence to green procurement practices.

2.5.2 Leadership and Corporate Strategy

2.5.2.1 Top Management Commitment

Successful integration of green procurement into current corporate practices requires commitment from top management. This commitment is affected by the environmental vision of the company and the dedication of executive leadership, which is further reinforced by the support of mid-level management (Ruparathna and Hewage, 2015; Wong, Chan and Wadu, 2016).

Furthermore, internal management pressure is crucial for subordinates to adopt green procurement practices, particularly when choosing components and materials with lower environmental impacts. As a result, top management encourages mid-level managers and engineers to apply green procurement management while choosing construction materials (Koebel et al., 2015; Shen, Zhang and Zhang, 2017).

Awareness of the financial and environmental benefits, such as cost reduction and waste elimination, helps corporate management adopt green procurement practices more successfully (Wong, Chan and Wadu, 2016). When a company recognises these benefits and establishes sustainability as the organisational culture, the whole project team will be dedicated to attaining the greatest possible green performance for the construction projects (Bohari et al., 2017; Bidin et al., 2020).

Moreover, the management should conduct periodic evaluations to improve the effectiveness of green procurement practices. The purpose of this review is to emphasise the significance of green procurement procedures, promote departmental collaboration as well as assist in making informed purchasing decisions (Bohari et al., 2017; Bidin et al., 2020). According to a study conducted in Hong Kong, the implementation of green procurement practices can be strengthened by having an internal sustainability policy, a green procurement initiative or appropriate staff training within a company (Wong,

Chan and Wadu, 2016). Additionally, a study in Canada discovered that 66% of construction companies implemented documented procurement manuals to define and promote the sustainability goals of the companies (Ruparathna and Hewage, 2015). Similarly, a study in Malaysia also supports that adopting green procurement practices is largely driven by top management action (Razali et al., 2021). Thus, the active involvement and commitment of top management are vital for advancing green procurement practices.

2.5.2.2 Corporate Social Responsibility (CSR)

A country's technological advancement, social development and economic growth are significantly influenced by construction firms. Natural resources are necessary for firms to utilise as raw materials and energy to enable construction to be carried out. However, enterprises that prioritise maximising profits over environmental considerations will excessively utilise the resources and cause ecological imbalance. This could result in significant financial losses and compel the firms to cease operations due to a shortage of sufficient natural resources (Su, Liu and Zhang, 2024). As a result, this raises awareness among construction firms regarding the necessity of promoting green construction. An increasing level of environmental policy integration into business operations demonstrates a construction firm's commitment to Corporate Social Responsibility (CSR) (Wong, Chan and Wadu, 2016; Yap et al., 2024b). According to Khojastehpour and Shams (2020), CSR shows that a firm will take environmental and social concerns into account while achieving economic objectives.

Studies conducted in China and Malaysia underscore the significant mediating contribution to the interaction between CSR and sustainable development goals. The study in China indicates that the integration of CSR with green procurement practices significantly improves the achievement of sustainable development. This is because the encouragement of environmentally conscious purchasing aids in achieving sustainability goals such as lowering carbon dioxide emissions and enhancing ecosystem sustainability. On the other hand, the study in Malaysia emphasises the significance of coercive pressures, such as government regulations and policies, in enhancing the benefits of CSR. These regulations and policies ensure that

firms adhere to environmentally responsible practices, which further promote sustainability in construction practices (Avotra et al., 2021; Ajibike et al., 2023).

2.5.2.3 Enhance Reputation of Client Companies

Gaining and retaining a competitive advantage requires a solid reputation. Rather than expanding advertising, a construction firm might enhance its reputation by carrying out positive actions and managing resources and capabilities appropriately. Nowadays, owing to environmental degradation, sustainability is one of the crucial criteria for a firm to maintain a positive reputation (Quintana-García, Benavides-Chicon and Marchante-Lara, 2021)

Hazardous substances may be released during construction operations if the construction project is utilising conventional construction materials. In order to mitigate these risks, developers are shifting to green procurement. This change can enhance the companies' public image and satisfy the public's increasing demand for sustainability. As a result, the enhanced environmental image of a company also affects customer choices when it comes to property purchasing (Shen, Zhang and Zhang, 2017).

In some cases, private developing companies occasionally utilise green procurement to strengthen relationships with contractors and suppliers. This is because cooperation among contractors and suppliers is required to create alternative environmentally friendly products. This collaboration not only results in the production of such products but also increases customer satisfaction and retention (Khan et al., 2018).

Furthermore, adhering to green procurement regulations promotes positive company images and enduring customer loyalty, particularly for small and medium-sized construction firms (SMEs) (Chinomona and Omoruyi, 2018; Yap et al., 2024b). Overall, green procurement is essential for developers to handle environmental issues, enhance economic positions and uphold their good reputations (Wong, Chan and Wadu, 2016; Yap et al., 2024b).

2.5.3 Economic and Market Dynamics

2.5.3.1 Achieving Cost Savings

Adoption of green procurement strategies is driven by an attraction for business benefits, such as cost reduction, waste minimisation and quality enhancement.

For instance, developers in the US regularly utilise green materials in construction projects due to the recognition of cost-saving potential and the environmental benefits of the materials. Similarly, developers in China are driven to procure fibreglass window products with superior thermal insulation as these products have lower costs by eliminating the requirement for steel reinforcement (Shen, Zhang and Zhang, 2017).

There are significant long-term financial benefits for green procurement practices even though the initial cost of implementing these practices is frequently greater than that of conventional approaches (Adebayo, Paul and Eyo-Udo, 2024). This is due to the fact that utilising green materials raises the total investment required for construction projects by 8.5% to 13.9% and the adoption of advanced construction methods and technologies as well as the necessary staff training raises the initial investment. However, despite these higher initial costs, green procurement practices can greatly lower environmental expenses and improve environmental performance (Wong, Chan and Wadu, 2016; Shen, Zhang and Long, 2017).

Furthermore, energy and resource consumption as well as utility and disposal expenses can be reduced through the utilisation of energy-efficient designs and recyclable products. For example, contractors can benefit from reduced fees for managing hazardous materials and waste as well as decreased administrative reporting costs associated with these construction-related tasks. Additionally, green materials also provide savings since these materials require less energy, water and fuel consumption, which directly lowers the long-term utility and operating costs (Shurrab, Hussain and Khan, 2019). Thus, the greater upfront expenditures can be offset by the savings realised over the operation and maintenance phases (Yap et al., 2024b).

Abushanab and Alnahhal (2023) conducted a study in Qatar to examine the life cycle costs of green buildings. The findings claim that green buildings constructed with treated wastewater, recycled concrete aggregates and fly ash incur maintenance and life cycle costs that were 60.18% and 19.21% lower, respectively, compared to conventional buildings constructed with fresh water, natural aggregates and 100% Ordinary Portland Cement.

2.5.3.2 Market Demand

As global awareness of environmental protection grows, environmentally friendly construction products are becoming more widely recognised. This further creates a strong market demand for environmentally friendly and cost-saving construction materials (Wong, Chan and Wadu, 2016). In response to this demand, developers in the US have embraced green procurement practices by integrating green building technologies into construction projects. Technologies including high energy efficient windows, cross-linked polyethylene water distribution piping and programmable thermostats are utilised to lower energy consumption and improve efficiency (Koebel et al., 2015; Sanderford et al., 2015; Shen, Zhang and Zhang, 2017). Similarly, several prominent Chinese developers have started introducing green products into residential projects as a response to market demands (Shen, Zhang and Zhang, 2017). As market demand for green products increases, clients are more likely to recognise the potential outcomes of green procurement implementation (Sajjad et al., 2021). This observation is supported by a Canadian study which identifies that the implementation of green procurement practices is driven by client demand (Ruparathna and Hewage, 2015).

2.5.3.3 Gain Competitive Advantage in Market

The pressure from competitors serves as a facilitator for adopting green policies within the construction industry. Wong, Chan and Wadu (2016) highlight that the developers have a proactive role in promoting green culture and implementing green policies in construction firms can assist the firms in gaining marketing benefits. For instance, integrating green materials into construction projects can help the developer stand out from competitors and attract environmentally conscious consumers due to the unique and appealing nature of the green products (Shen, Zhang and Zhang, 2017). Furthermore, incentives can be provided by developers to contractors who fulfil the project sustainability requirements. By incorporating these incentive provisions in the contract, developers can make their portfolio more competitive and marketable as contractors will be motivated to engage in green projects (Wong, Chan and Wadu, 2016). Similarly, introducing green criteria in the tendering process motivates contractors to develop innovative solutions to comply with these

requirements, thus boosting competitiveness and capabilities within the market (Khan et al., 2018). Besides, the utilisation of green building technologies can provide competitive advantages by enhancing public image and reputation, which in turn can lead to increased market opportunities (Chan, Darko and Ameyaw, 2017). In addition, Yap et al. (2024b) and Liu, Liu and Yang (2020) underscore that adopting green procurement policies leverages the company's commitment to sustainability, providing a competitive edge in the local construction market. The researchers suggest that construction firms can consider green procurement as an environmental competency that aids in maintaining their market position and achieving long-term success.

2.5.4 Environmental and Social Responsibility

2.5.4.1 Environmental Sustainability

In the construction industry, green procurement practices are largely driven by environmental sustainability. Since awareness is a prerequisite for decision-making adoption as well as attitude and behaviour changes, the successful implementation of green procurement practices has been aided by the increased public understanding of environmental sustainability (Nadeem, Mohamad and Nik Abdullah, 2017; Bonoli, Zanni and Serrano-Bernardo, 2021). Moreover, the use of the Internet greatly raises awareness of environmental sustainability. A study conducted by Yang et al. (2023) demonstrates this by emphasising that Eastern China has a much higher level of green development compared to the Western region. According to Zhang and Gong (2023), this greater environmental sustainability awareness level in Eastern China is enhanced by the widespread use of the Internet.

Furthermore, the increased awareness encourages contractors to adhere to environmental regulations such as ensuring timber materials are sourced from legally harvested forests (Khan et al., 2018). The benefits of green procurement, such as the potential capacity to reduce air, noise, water and soil pollution, are also introduced through awareness. Stakeholders can lower the toxic gas emissions into the atmosphere by regulating the chemical and hazardous content of the construction materials. Global warming is able to be minimised since green procurement practices lower greenhouse gas emissions at every phase of the construction project lifecycle (Vejaratnam, Mohamad and Chenayah, 2020;

Yap et al., 2024b). According to Wu, Zhang and Wu (2016), air quality can be enhanced by introducing green practices into the transportation and demolition processes to reduce construction dust. Besides, the reduction of ashes and flue gases produced during the incineration process is able to be achieved by reusing construction waste for new raw materials (Bonoli, Zanni and Serrano-Bernardo, 2021). In addition, Bohari et al. (2024) underscore that the adoption of various innovative green practices in the construction industry is essential to slow down the natural resource depletion.

2.5.4.2 Provide Healthier Working Environment

Implementing green procurement practices significantly contributes to creating a healthier working environment in the construction industry. According to Ruparathna and Hewage (2015) and Yap et al. (2024b), implementing green practices and procedures minimises absenteeism and adverse effects on workers' health. Thus, increased productivity among workers will result from a better working environment. For example, adopting green procurement practices makes the workplace healthier and more comfortable for construction workers, which reduces the incidence of allergies, asthma attacks and headaches. Contractors can contribute to a healthier workplace by using less harmful chemicals, lowering health risks and eliminating expenses associated with reporting accidents and managing hazardous materials. Moreover, improving air and water quality at construction sites can enhance the health of construction workers, which in turn boosts the workers' productivity. In the end, this productivity boost benefits citizens and public agencies by improving project performance and quality (Khan et al., 2018).

2.5.4.3 Improving Community Health and Quality of Life

Enhancing community health and quality of life is increasingly recognised as a critical driver for the implementation of green procurement practices. This is because these practices contribute to healthier environments by reducing the usage of toxic materials, enhancing the air and water quality as well as minimising waste disposal (Ruparathna and Hewage, 2015; Shurrab, Hussain and Khan, 2019). For example, by adopting the reuse and recycling of construction waste, the levels of air pollution are significantly reduced

compared to traditional waste disposal methods such as incineration. In addition, buildings that incorporate green features, such as green roofs, are known to lower interior temperatures by up to 2.3°C and provide superior indoor air quality (Ofek, Akron and Portnov, 2018; Yap et al., 2024b). Green roof systems also provide efficient rainwater management, on-site gardens and protection against Ultraviolet (UV) light, thereby reducing potential health risks for occupants (Khan et al., 2018). According to a study conducted in India, hospitals that adopted green practices such as incorporating solar lighting, green cement, fly ash, green roofs and rainwater harvesting enhance the quality of life for building occupants while also lowering employee absenteeism (Tarkar, 2022). These improvements in health and well-being demonstrate the broader public benefits of green procurement decisions, underscoring the significance of enhancing community health and quality of life as a primary motivator for green procurement.

2.5.5 Innovation and Technological Advancement

2.5.5.1 Innovation and Technology

The successful adoption of green procurement is closely linked to the innovation and integration of advanced technologies in construction. According to Sajjad et al. (2021), advanced building technology encompasses a wide range of innovations including the latest advancements in materials research, structural assessment, planning procedures and management approaches. As the world proceeds towards Industrial Revolution 5.0 (IR 5.0), the construction industry is progressively implementing more environmentally friendly and sustainable solutions. This shift is supported by national policies such as the Construction Industry Transformation Program (CITP), Green Technology Master Plan (GTMP) and 12th Malaysian Plan (RMK-12) in Malaysia, which encourage the use of advanced technologies including the Industrialised Building System (IBS), 3D printing, BIM, autonomous construction equipment and advanced construction materials (Masyhur et al., 2024).

To realise these advancements, green innovation is essential as green innovation integrates the development of environmentally friendly products with sustainable practices with the aim of lowering energy consumption, harmful emissions and waste while increasing overall efficiency and financial

benefits (Saudi et al., 2019). This innovation is vital for achieving the construction industry's goal of net-zero carbon emissions and aligning with global environmental objectives. Artificial Intelligence (AI) is at the forefront of this technological evolution which significantly enhances building designs for greater efficiency in energy usage and less adverse environmental effects. As a result, knowledgeable judgments that meet strict green standards and requirements can be made by the architects and engineers. AI also drives innovation in construction materials and technologies by improving their durability, safety and efficiency. AI and machine learning are being utilised to produce novel construction materials and investigate solutions to climate change. This is due to AI integrating data from sensors, drones, BIM models and historical projects to help optimise resource allocation, streamline project management, and guarantee real-time adherence to green standards and requirements. Moreover, AI helps improve supply chains for the construction industry by lowering energy usage in logistics. AI also increases the effectiveness and reliability of the waste management process by construction waste are correctly classified for recycling. Furthermore, better decision-making and encouraging green procurement practices can be facilitated by incorporating AI into life cycle assessment as the ecological damage of construction materials and products is being evaluated (Regona et al., 2024).

2.5.5.2 Provide Proper Assessment Tool

In the effort to enhance green procurement adoption, providing appropriate assessment tools that guarantee sustainability throughout a project lifecycle is highly effective. According to Bidin et al. (2020), environmental assessments can provide substantial information for construction team members throughout the design process by assessing the potential effects of a project. Thus, construction team members are better able to maintain sustainable standards from inception through completion.

A crucial instrument in green procurement strategies is the Green Building Index (GBI). A study conducted in South Korea highlights that taking into account life cycle carbon emissions and carbon economic efficiency during the calculation of green building certification rating is more quantitative than the Green Standard for Energy and Environmental Design (G-SEED). This is

due to G-SEED does not completely integrating the financial benefits of lowering carbon emissions, but the former does. As a result, this eventually helps to reduce carbon emissions in new construction projects (Roh, Tae and Kim, 2018). Similarly, numerous green building rating systems across the globe are essential for encouraging green construction. According to a study conducted in Italy, systems such as Leadership in Energy and Environmental Design Standards (LEED) in the US, ITACA protocol in Italy, Green Star rating system in Australia, Building Research Establishment Environmental Assessment Methodology (BREEAM) in the UK and Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan are being utilised to evaluate the construction buildings to lower energy consumption and minimise adverse environmental impacts. The researchers recommend that various factors, such as seismic risks, Life Cycle Assessment (LCA) aspects, recycling and repurposing of construction waste, urban heat island effect, global warming as well as noise and light pollution should be taken into account in order to achieve thorough sustainability certification (Mattoni et al., 2018).

Furthermore, LCA helps assess the environmental impacts of infrastructure projects and products throughout the project lifecycle, from raw materials extraction to disposal at the end of their usable life. In particular, LCA aids in deciding green materials and practices for road construction, which often involves large-scale raw materials and fuel consumption. However, a study carried out in India draws attention to the implication of LCA in road construction has been limited to developing countries such as India due to funding constraints and difficulties in data collection (Chaudhary and Akhtar, 2024; Khan, Balunaini and Costa, 2024).

Moreover, another essential assessment for guaranteeing project sustainability is the Environmental Impact Assessment (EIA). Nevertheless, diverse risk scenarios and ever-changing environmental conditions pose challenges for EIA. This underscores the necessity for thorough assessment tools to deal with environmental concerns in the long term as well as increase the precision of prediction (Yuan et al., 2023). This opinion is supported by a Czech study, noting that EIA predictions are reliable throughout the construction period and the first year of usage, but the projections are generally

inaccurate in predicting medium to long-term cumulative environmental impacts. The researchers emphasise that predictions can be improved by enhancing the coordination between the Strategic Environmental Assessment (SEA) and EIA procedures as well as the effective integration of zoning planning, project design and EIA processes (Zítkova et al., 2022).

2.5.6 Stakeholder Engagement and Collaboration

2.5.6.1 Stakeholder Values Towards Greening Construction Procurement

According to Bidin et al. (2020), stakeholder perceptions have a substantial impact on the outcomes of construction projects while stakeholder commitment, capability and motivation are necessary components for project success. This underscores the significance of effective communication and maintaining the interest of every construction team member, including clients, consultants, contractors, subcontractors and suppliers. Moreover, Bohari et al. (2017) underscore the importance of continuous training and knowledge sharing among stakeholders. Along with raising awareness, the training and eagerness to share knowledge about green projects also demonstrate the stakeholders' capacity to ensure the project’s success.

Furthermore, effective management of the green supply chain requires mutual commitment and collaboration between stakeholders. Supplier audits are essential to enhance the efficiency of green procurement practices. However, the adoption of these practices may be hindered by the immaturity of the market and the preference of architects and contractors for budgetary constraints. These difficulties can be resolved by conveying to clients the benefits of green design and engaging the assistance of environmental engineers to offer guidance in the selection of environmentally friendly products (Wong, Chan and Wadu, 2016).

In addition, leveraging professional judgment and past experiences is vital for sustainable construction. Nevertheless, a Canadian study by Ruparathna and Hewage (2015) highlights that only a limited number of construction projects require contractors to provide proof of their prior green construction expertise. Generally, such green projects are only taken on by environmentally conscious stakeholders (Fu et al., 2020).

2.5.6.2 Corporation and Partnership

The application of green procurement can be enhanced through cooperation and partnership among construction firms and investors. According to Sajjad et al. (2021), the formation of Joint Ventures (JV) can combine resources, reduce risks and enhance profitability while at the same time promoting green construction practices.

One of the most impactful forms of partnership is through Public-Private Partnerships (PPPs), which are essential for integrating green practices into infrastructure projects such as highways, railways and bridges to accomplish SDGs. This form of partnership enables the private construction sector to be involved in the design, construction, operation and maintenance phases of the projects. A study carried out in Australia highlights that PPPs help embrace sustainability performance requirements, comply with green benchmarks and foster social diversity (Akomea-Frimpong, Jin and Osei-Kyei, 2022). However, the sustainability outcome of the projects highly depends on the distribution of investment between the public and private construction sectors. Better sustainability outcomes can be obtained if investments are appropriately distributed between the two sectors. Generally, the public sectors prioritise social and environmental issues while the private sectors concentrate on financial advantages. Thus, by integrating these economic, social and environmental factors appropriately, projects can contribute more effectively to sustainability objectives in the construction industry (Shen et al., 2016).

In addition to that, partnerships involving Governmental Venture Capital (GVC) have emerged as pivotal in promoting green procurement. A study conducted in China underscores that GVC investments have a noteworthy and advantageous effect on green innovation. These partnerships are particularly valuable in overcoming the high upfront costs, risks and uncertainties of green innovation, which frequently discourage private sector participation. Through GVC, there is a greater availability of financial resources for the development and implementation of green building technologies, green construction materials and practices (Li et al., 2024).

2.5.6.3 Suppliers-Induced Benefits

Suppliers-induced benefits are a significant driver of green procurement. In order to minimise the overconsumption of natural resources, construction firms are gradually shifting to a shared commitment to environmental sustainability rather than merely transactions. This shift creates a shared objective of sustainability and environmental consciousness by fostering collaborations that go beyond issues of cost and accessibility. Such collaborations are crucial for leading the construction industry towards a greener future by incorporating green practices from sourcing raw materials to the execution of projects (Ali et al., 2023). Furthermore, there are tangible benefits to the partnerships of developers and green materials suppliers. These partnerships ensure the continual quality of construction materials and products while also offering opportunities to benefit from discounts and the adoption of advanced green technologies (Shen, Zhang and Zhang, 2017). Thus, construction firms can overcome obstacles to implementing new technologies and procedures by establishing such partnerships. According to Rizos and Bryhn (2022), enhanced cooperation eventually leads to more efficient and greener procurement methods by enhancing transparency throughout the supply chain and facilitating the sharing of vital information on circularity.

2.5.7 Supply Chain and Resource Availability

2.5.7.1 Availability of Green Products and Services

The availability of green products and services in the market will drive the implementation of green procurement practices. As the construction industry increasingly strives to meet sustainability targets, the presence of environmentally friendly materials and technologies is essential in reducing the ecological footprint (Nadeem, Mohamad and Nik Abdullah, 2017; Razali et al., 2021). The growing access to environmentally friendly solutions is driving the innovation in green products, which is regarded as essential to attaining development, environmental sustainability and enhanced quality of life. These innovative green products offer a competitive advantage and greatly improve the business operations of construction firms (Hariadi, Moengin and Maulidya, 2023).

According to Khaderi et al. (2022) and Yap et al. (2024a), developers often view the high costs of green products and services, coupled with a lack of incentives, as significant barriers to implementing green procurement in the construction industry. However, the dynamics of supply and demand in the market may cause prices of these products and services to decline as their availability rises. The expanded availability can foster greater market competition, making green products and services more affordable and accessible. In this situation, consultants and contractors can assess the features and expenses of various green products more efficiently to choose the most appropriate options for construction projects. As a result, the ability to evaluate and compare green products based on price and features promotes more informed decision-making and facilitates the wider adoption of green procurement practices.

2.5.7.2 Availability of Green Suppliers

Since the development of green procurement practices and green suppliers is closely interconnected, the availability of green suppliers is essential as a driver of green procurement practices. In conventional practices, the selection of suppliers for construction projects often omits ecological efficiency in favour of technological and financial efficiency. However, due to the greater dedication to environmental conservation and the long-term implications on business, construction firms now prioritise suppliers' environmental consciousness when selecting suppliers for a particular project (Quan, Zeng and Liu, 2018; Konys, 2019). As a result, green suppliers are actively involved in producing greener products in an environmentally friendly manner to improve the environmental performance of these products (Blome, Hollos and Paulraj, 2014). According to Woo et al. (2016), these green suppliers also manufacture eco-friendly materials and incorporate green product designs for construction partitioners.

Furthermore, a study conducted by Blome, Hollos and Paulraj (2014) also emphasises that prompt and regular communication regarding green performance issues can lead to the improvement of suppliers' environmental performance. Moreover, the adoption of green procurement practices in the construction industry is significantly supported by the suppliers’ awareness of regulations related to the contracting and tendering of green products (Nadeem,

Mohamad and Nik Abdullah, 2017). Therefore, rewarding suppliers for their green performance, such as awarding extra points to those who produce products with a higher percentage of recycled content, can motivate and acknowledge these efforts (Rainville, 2017).

2.5.7.3 Establishment of Reliable Database

The establishment of a reliable database of green procurement is crucial for driving green procurement practices. A study conducted by Wong, Chan and Wadu (2016) emphasises that the public should have access to a comprehensive database that has precise data on the energy consumption and hazardous gas emissions of various types of materials. The availability of such data guarantees the reliability of green product information and results in helping construction industry participants, including consultants, contractors, and developers, to make well-informed decisions. The findings of this study also underscore the adoption of well-defined, performance-based specifications from prospective suppliers along with collaboration with environmental organisations such as the Green Council and suppliers to enhance the Hong Kong Green Label Scheme (HKGLS) can further contribute to providing a standardised, trustworthy and publicly accessible database of green specifications.

According to Palii et al. (2024), the reliable database of recycled concrete aggregates provides standard information on the properties, performance and potential applications in green procurement practices. This information guarantees quality control as well as encourages research and innovation in sustainable concrete technology. Additionally, Nketiah et al. (2024) emphasise that a well-maintained database of green procurement can significantly bolster R&D activities by offering comprehensive information on existing practices and identifying areas for improvement. More effective R&D activities will make it possible to identify green procurement practices that minimise resource consumption and environmental impact while promoting sustainability. A study carried out in South Korea thoroughly examines the heating energy consumption of service apartments in Seoul and Busan. The findings demonstrate that trends in energy consumption over time have been assessed by utilising a national energy database. Therefore, these data allow for

the prediction of potential energy efficiency enhancements in older buildings through green renovations (Seo, Jung and Rhee, 2023).

Table 2.2: Literature Map for Drivers of Green Procurement Practices.

Ref	Drivers	No of Studies	Sources
	Policy and governance support		
D1	Availability of policies and guidelines	7	Ruparathna and Hewage (2015), Wong, Chan and Wadu (2016), Razali et al. (2021), Bidin et al. (2020), Shen, Zhang and Zhang (2017), Wong and Loo (2022), Wuni et al. (2022)
D2	Regulations and standards of green procurement	7	Wong, Chan and Wadu (2016), Nadeem, Mohamad and Nik Abdullah (2017), Zeng et al. (2003), Shurrab, Hussain and Khan (2019), Kineber, Kissi and Hamed (2022), Eze, Sofolahan and Omoboye (2023), Shen, Zhang and Zhang (2017)
D3	Implementation of incentive policies	8	Ruparathna and Hewage (2015), Wong, Chan and Wadu (2016), Razali et al. (2021), Bohari et al. (2017), Bidin et al. (2020), Shen, Zhang and Zhang (2017), Nadeem, Mohamad and Nik Abdullah (2017), Tong and Li (2018)
D4	Campaigns and workshops	5	Nadeem, Mohamad and Nik Abdullah (2017), Razali et al. (2021), Masyhur et al. (2024), Ikau and Joseph (2017), Bidin et al. (2020)
	Leadership and corporate strategy		
D5	Top management commitment	7	Ruparathna and Hewage (2015), Wong, Chan and Wadu (2016), Koebel et al. (2015), Shen, Zhang and Zhang (2017), Bohari et al. (2017), Bidin et al. (2020), Razali et al. (2021)
D6	Corporate social responsibility (CSR)	6	Su, Liu and Zhang (2024), Wong, Chan and Wadu (2016), Yap et al. (2024b), Khojastehpour and Shams (2020), Avotra et al. (2021), Ajibike et al. (2023)
D7	Enhance reputation of client companies	6	Quintana-García, Benavides-Chicon and Marchante-Lara (2021), Shen, Zhang and Zhang (2017), Khan et al. (2018), Chinomona and Omoruyi (2018), Yap et al. (2024b), Wong, Chan and Wadu (2016)
	Economic and market dynamics		
D8	Achieving cost savings	5	Shen, Zhang and Zhang (2017), Adebayo, Paul and Eyo-Udo (2024), Wong, Chan and Wadu (2016), Shurrab, Hussain and Khan (2019), Yap et al. (2024b), Abushanab and Alnahhal (2023)
D9	Market demand	6	Wong, Chan and Wadu (2016), Koebel et al. (2015), Sanderford et al. (2015), Shen, Zhang and Zhang (2017), Sajjad et al. (2021), Ruparathna and Hewage (2015)
D10	Gain competitive advantage in market	6	Wong, Chan and Wadu (2016), Shen, Zhang and Zhang (2017), Khan et al. (2018), Chan, Darko and Ameyaw (2017), Yap et al. (2024b), Liu, Liu and Yang (2020)

Table 2.2: Literature Map for Drivers of Green Procurement Practices (Continued)

Ref	Drivers	No of Studies	Sources
	Environmental and social responsibility		
D11	Environmental sustainability	10	Nadeem, Mohamad and Nik Abdullah (2017), Bonoli, Zanni and Serrano-Bernardo (2021), Yang et al. (2023), Zhang and Gong (2023), Khan et al. (2018), Vejaratnam, Mohamad and Chenayah (2020), Yap et al. (2024b), Wu, Zhang and Wu (2016), Bonoli, Zanni and Serrano-Bernardo (2021), Bohari et al. (2024)
D12	Provide healthier working environment	3	Ruparathna and Hewage (2015), Yap et al. (2024b), Khan et al. (2018)
D13	Improving community health and quality of life	6	Ruparathna and Hewage (2015), Shurrab, Hussain and Khan (2019), Ofek, Akron and Portnov (2018), Yap et al. (2024b), Khan et al. (2018), Tarkar (2022)
	Innovation and technological advancement		
D14	Innovation and technology	4	Sajjad et al. (2021), Masyhur et al. (2024), Saudi et al. (2019), Regona et al. (2024)
D15	Provide proper assessment tool	7	Bidin et al. (2020), Roh, Tae and Kim (2018), Mattoni et al. (2018), Khan, Balunaini and Costa (2024), Chaudhary and Akhtar (2024), Yuan et al. (2023), Zítkova et al. (2022)
	Stakeholder engagement and collaboration		
D16	Stakeholder values towards greening construction procurement	5	Bidin et al. (2020), Bohari et al. (2017), Wong, Chan and Wadu (2016), Ruparathna and Hewage (2015), Fu et al. (2020)
D17	Corporation and partnership	4	Sajjad et al. (2021), Akomea-Frimpong, Jin and Osei-Kyei (2022), Shen et al. (2016), Li et al. (2024)
D18	Suppliers-induced benefits	3	Ali et al. (2023), Shen, Zhang and Zhang (2017), Rizos and Bryhn (2022)
	Supply chain and resource availability		
D19	Availability of green products and services	5	Nadeem, Mohamad and Nik Abdullah (2017), Razali et al. (2021), Hariadi, Moengin and Maulidya (2023), Khaderi et al. (2022), Yap et al. (2024a)
D20	Availability of green suppliers	6	Quan, Zeng and Liu (2018), Konys (2019), Blome, Hollos and Paulraj (2014), Woo et al. (2016), Nadeem, Mohamad and Nik Abdullah (2017), Rainville (2017)
D21	Establishment of reliable database	4	Wong, Chan and Wadu (2016), Palii et al. (2024), Nketiah et al. (2024), Seo, Jung and Rhee (2023)

2.6 Summary

In essence, the definition, practices as well as drivers of green procurement were elaborated extensively. Additionally, the key findings gathered from several existing studies regarding the practices and drivers of green procurement are synthesised and presented in Tables 2.1 and 2.2. A comprehensive review of the literature reveals that green procurement practices can be categorised into conventional and innovative while the drivers can be categorised into policy and governance support, leadership and corporate strategy, economic and market dynamics, environmental and social responsibility, innovation and technological advancement, stakeholder engagement and collaboration as well as supply chain and resource availability. Figure 2.1 presents the conceptual framework illustrating the practices and drivers of green procurement within the construction industry.

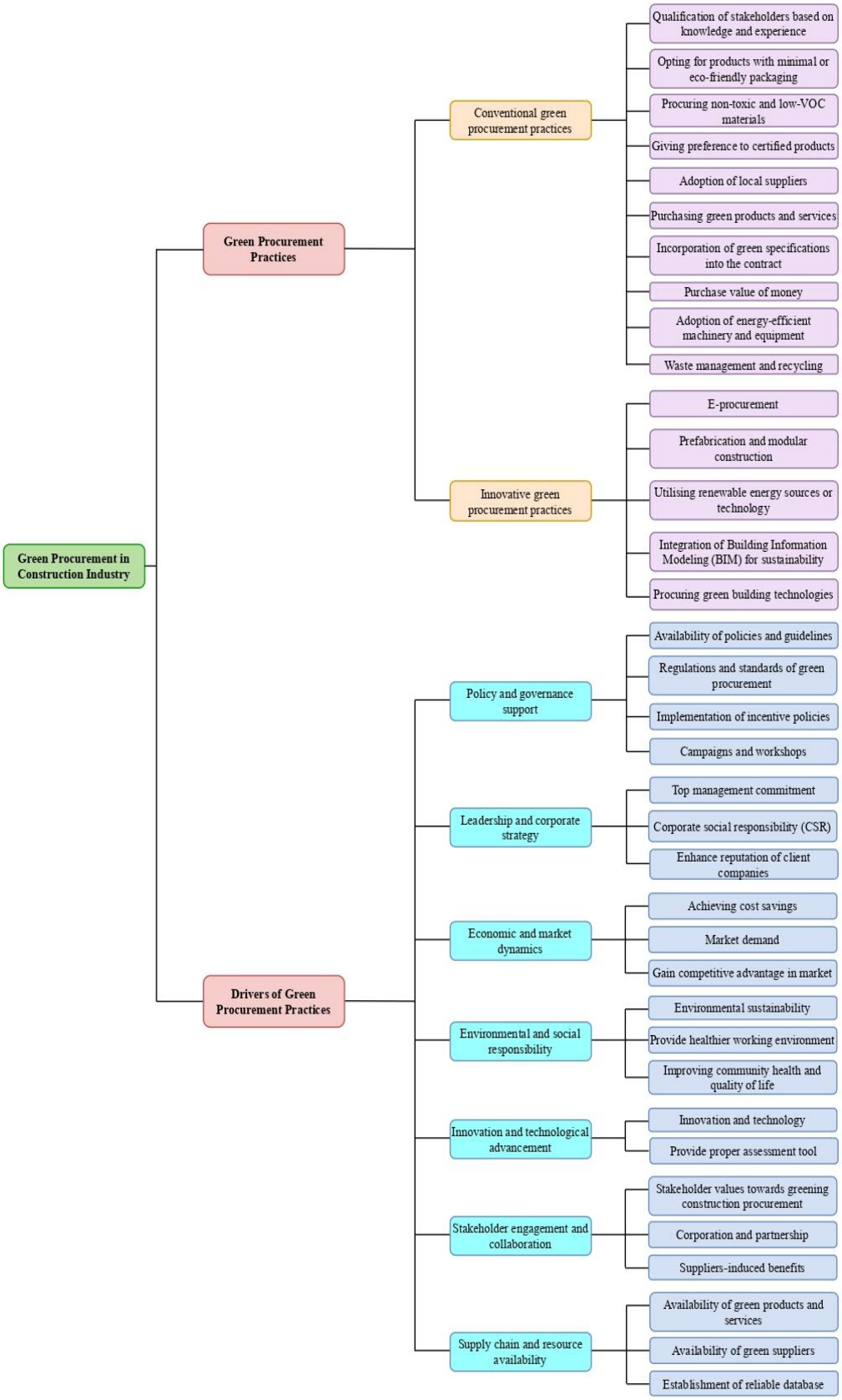

Figure 2.1: Conceptual Framework of Practices and Drivers of Green Procurement in Construction Industry.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

This chapter primarily covered the research methodology implemented in the study, aiming to uncover meaningful insights through scientific analysis and structured procedures applied to the collected data. It elaborates on the research framework, sampling strategy, data collection methods and analytical techniques employed to ensure methodological rigour and the reliability of the study's findings.

3.2 Research Methodology

Research methodology encompasses a systematic method for problem-solving in research that pushes the boundaries of knowledge (Patel and Patel, 2019). The quantitative approach and the qualitative approach are two different ways that the research methodology could be approached. For certain research topics, these two approaches can be used concurrently.

According to Taherdoost (2022), quantitative research is an approach that describes and analyses phenomena using numerical values obtained from observations. Numerical data are evaluated using statistical and mathematical techniques to ascertain the extent to which particular norms are met within a policy or program. On the contrary, qualitative research is an iterative process that aims to produce meaningful new distinctions that lead to a deeper knowledge of phenomena. The examination of meanings and the reasons underlying cultural symbols, individual experiences and circumstances is further emphasised in this research approach. Generally, case studies, interviews and observations are used as empirical materials by the researchers. In short, quantitative research differs from qualitative research in that the former focuses on numerical data while the latter is more concerned with comprehending the complicated processes and meanings that people attribute to their experiences (Aspers and Corte, 2019).

3.2.1 Selection of Quantitative Research

In this study, a quantitative approach is adopted. This is due to the quantitative approach is especially suited for cross-sectional studies, which require collecting data from multiple groups or individuals within a particular time frame. The speed and efficiency of the quantitative approach are another reason for its usage as this approach enables the quick and economical collection of a substantial number of responses in a relatively short period. Moreover, the quantitative approach facilitates the critical analysis of numerical data, which allows for a thorough assessment of the dependability of the outcomes. To gather data for this study, a questionnaire was developed featuring closed-ended questions with predetermined response options. This approach simplifies the process of quantifying results and enables efficient execution of statistical analyses.

3.3 Research Design

Research design presents the entire strategy for conducting, organising and carrying out this study (Saunders, Philip and Thornhill, 2019). The procedure involved in carrying out this study was illustrated and summarised in Figure 3.1.

Firstly, the background of the problem was ascertained, a concise problem statement was developed, the research scope was established as well as the research objectives were outlined in this study. The following step involved gathering more information from existing research papers regarding the practices and drivers of green procurement in the construction industry. After that, the sampling design was established, which involved selecting the sampling strategy, determining the sampling size, identifying the targeted respondents and an appropriate research strategy was put into place to ensure the successful execution of the study.

In this study, data were gathered in a proportionate manner from three distinct groups, which are clients, consultants and contractors. The sample size is designed to include a minimum of 110 participants, with each group contributing at least 30 respondents from each group. The sample size calculation was based on the Yamane formula, supported by the Central Limit Theorem (CLT) and the “rule of five” for factor analysis to ensure sufficient representation and statistical validity. Once the sample size is established, the

data collection approach is developed. Primary data for this study were gathered using a questionnaire survey. This survey comprised four sections, with Section A concentrating on acquiring demographic information from the targeted respondents while Sections B and C employed a five-point Likert scale. Section D included questions with varied response formats, specifically designed to suit the nature of each question. Moreover, the data that was collected was analysed using the Statistical Package for Social Sciences (SPSS). Finally, the summaries, recommendations and conclusions were produced based on the findings.

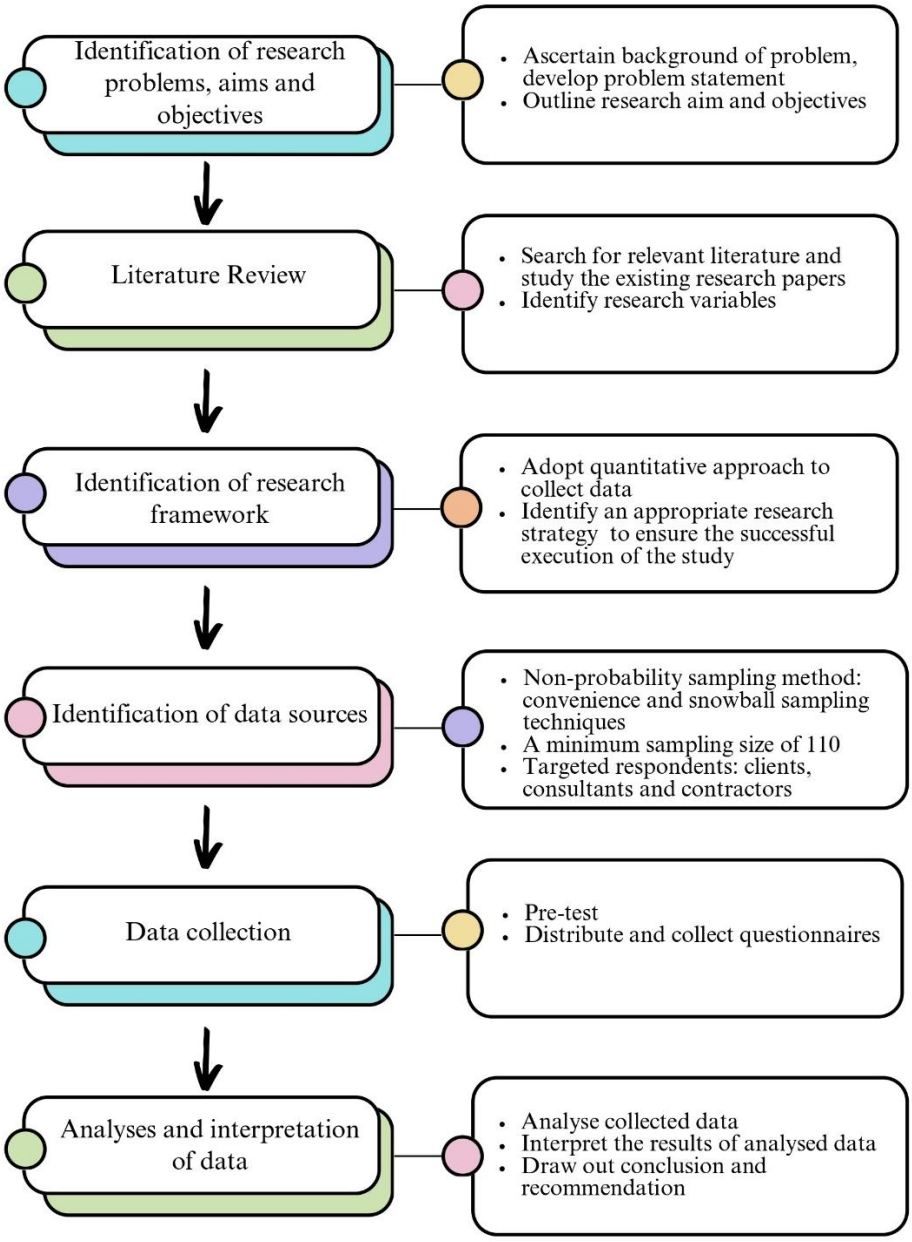

Figure 3.1: Flowchart for Research.

3.4 Sampling Design

3.4.1 Sampling Method

As illustrated in Figure 3.2, sampling techniques can be categorised into probability and non-probability sampling. With probability sampling, there is an equal chance of selection for each individual in the population. On the contrary, non-probability sampling permits more direct data collection since it does not provide a basis for calculating the possibility that a specific component of the population will be represented in the sample (Etikan, 2017).

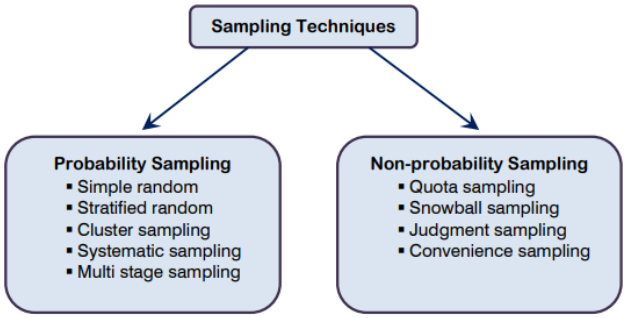

Figure 3.2: Sampling Techniques.

Source: Taherdoost, 2018.

Non-probability sampling method is employed in this study. Taherdoost (2018) emphasises that quota sampling is utilised to ensure at least 30 responses from each group, including clients, consultants and contractors, in order to guarantee that the sample accurately reflects the distribution of specific characteristics within the entire population. In particular, the convenience and snowball sampling techniques are applied. Convenience sampling involves selecting industry professionals who are easily accessible, available during the study period or willing to take part in the questionnaire (Etikan, 2016). Furthermore, snowball sampling is employed to expand the sample size by depending on the initial respondents to enlist additional members from related groups. This strategy requested the first participant to suggest two other professionals in their network who fit the study criteria. Subsequently, these new participants suggested additional individuals to further enhance connections.

3.4.2 Sampling Size

According to Muyembe Asenahabi and Anselemo Ikoha (2023), a sample size refers to a subset of a population chosen to represent the whole population in a study. In certain circumstances, smaller sample sizes are adopted due to the rarity of the study topic or the high cost and complexity of data collection. However, an extremely small sample size may compromise the reliability of findings and hinder the ability of future researchers to replicate them. On the other hand, an excessively large sample size may identify may detect differences that are statistically noticeable but have little practical or real-world relevance. Thus, determining an appropriate sample size is essential to guaranteeing that there is sufficient statistical power to detect real effects, facilitate thorough reporting and enable careful interpretation of the results (Althubaiti, 2023). Adam (2020) and Sharma and Bhattarai (2024) underscore that the sample size for a finite population can be calculated using the Yamane formula. The formula is shown in Eq. 3.1.

$$n = \frac{\mathrm{N}}{1+N\,(e)^2} \tag{3.1}$$

Where,

n = ideal sample size

N = population size

e = level of precision

In this study, the target population consists of approximately 20,000 construction practitioners in the construction industry. Although a 5% precision level is commonly applied in survey studies for greater statistical accuracy, this study adopts a 10% precision level as a practical compromise between precision and feasibility. Employing a 5% margin of error would require a substantially larger sample size, which may not be practical due to constraints such as limited time and difficulties in accessing respondents. Thus, adopting a 10% precision level allows the study to retain an acceptable degree of accuracy and statistical reliability while ensuring that data collection efforts remain manageable within the study's logistical limitations (Israel, 1992; Muyembe Asenahabi and

Anselemo Ikoha, 2023). Based on this, the sample size calculation at a 95% confidence level and 10% precision level is presented as follows:

$$n = \frac{20{,}000}{1 + 20{,}000\ (0.10)^2} = 99.5 \approx 100$$

Therefore, a minimum of 100 respondents is required to achieve an acceptable level of accuracy while maintaining practical feasibility.

In addition, the Central Limit Theorem (CLT) is utilised in this study to reinforce the rationale for ensuring an adequate number of respondents within each subgroup. Sample sizes generally greater than 30 are thought to be sufficient to guarantee a normal distribution of sample means (Islam, 2018). Additionally, the clients, consultants and contractors are the three sample groups that this study focuses on. Therefore, a minimum of 30 responses from each group is mandated, resulting in a total minimum sample size of 90. The application of CLT also justifies the need for balanced and adequate representation, which is particularly beneficial for the Kruskal-Wallis H test. Although this test is non-parametric, having balanced and sufficiently large group sizes helps stabilise rank distributions and enhances the test's ability to detect genuine differences between three respondent groups. Therefore, applying CLT principles improves the reliability and interpretability of the group comparisons conducted in this study.

However, in order to fulfil the essential requirements for conducting the Factor Analysis, this study adopts the widely accepted rule of thumb recommending a minimum participant-to-variable ratio of 5:1 (Kyriazos, 2018). Since 21 variables have been identified as drivers of green procurement practices, a minimum sample size of 105 is required. This threshold is deemed adequate to ensure stable factor loadings and enhance the replicability of the factor structure. Larger sample sizes improve the accuracy of correlation estimates, reduce the impact of random error and outliers as well as increase the statistical power of the analysis. Furthermore, ensuring an adequate sample size supports the reliability and validity of the derived factor solution, which is critical for identifying meaningful constructs (DeVellis and Thorpe, 2022). The sample size calculation is presented as follows:

Minimum sample size required for group representation:

Based on the Central Limit Theorem, each respondent group (clients, consultants, and contractors) requires a minimum of 30 participants (Islam, 2018). Therefore, the minimum required sample size for group representation is calculated as follows:

$$30 \times 3 = 90 \text{ responses}$$

Minimum sample size required for Factor Analysis:

Based on the widely accepted rule of thumb, a minimum of five responses per variable is required for factor analysis (Memon et al., 2020). As 21 variables related to the drivers of green procurement have been identified in this study, the minimum required sample size is calculated as follows:

$$21 \times 5 = 105 \text{ responses}$$

Since 105 exceeds the minimum group representation requirement of 90, the minimum required sample size for this study is 105 respondents. Nevertheless, to ensure robust statistical power and generalisability, this study attempts to gather 110 responses, thereby enhancing the overall reliability and validity of the results. This slight oversampling provides a margin of safety against non-responses or incomplete data, while also enhancing the stability of correlation estimates and reducing the potential influence of outliers.

Moreover, findings from related studies in similar contexts offer additional support for the calculated sample size. For instance, a study conducted in Vietnam with a sample size of 100 participants sought to determine the factors that drive innovation in sustainable construction. 125 responses were obtained from the questionnaire survey that was conducted utilising the snowball sampling approach and 102 valid responses were retained for analysis, resulting in an 82% response rate (Van Nguyen, 2023). Similarly, a study conducted in Hong Kong aimed to pinpoint essential factors that facilitate green procurement and propose recommendations for its effective adoption in the construction industry. In this study, the sample size is 120 and 84 valid

responses were received out of the 120 distributed questionnaires, yielding a 70% response rate (Wong, Chan and Wadu, 2016). Furthermore, a study carried out in Malaysia examined the level of readiness, challenges and significant drivers among construction enablers for implementing green procurement. A response rate of 85% was attained by the study, which had a sample size of 102 and 87 valid responses out of 102 disseminated questionnaires (Razali et al., 2021).

Based on the findings from the aforementioned studies, a sample size of approximately 100 participants is commonly considered sufficient to produce reliable and meaningful results. Therefore, the calculated sample size of at least 110 responses is deemed appropriate and adequate for this study.

3.4.3 Target Respondents

This study primarily focuses on construction practitioners within the Klang Valley area. Klang Valley is a major contributor to construction activity and urban development in Malaysia. In the fourth quarter of 2023, the value of construction work completed in Malaysia was RM34.1 billion. Selangor contributed RM8.6 billion through civil engineering, residential and non-residential projects while the Federal Territories added RM4 billion, in residential and non-residential construction (The Sun, 2024). Thus, Klang Valley is an ideal targeted area for this study due to the substantial level of construction activity in that particular area. Respondents were chosen from among those who have recently been involved in construction projects in a variety of roles, including clients, consultants and contractors. In this context, clients refer to developer firms in the construction industry, consultants include architects, engineers and quantity surveyors, while contractors encompass both main contractors and sub-contractors. As previously stated, at least 30 respondents from each sampling group must be obtained in order to guarantee that the total sample size for this study meets the requirement of at least 110 respondents.

3.5 Data Collection Method

3.5.1 Questionnaire Design

The questionnaire consists of four sections, each corresponding to the key objectives of the study. Section A is designed to gather the background of the

targeted respondents. Respondents are requested to rate their extent of agreement regarding the green procurement practices implemented in the Malaysian construction industry in Section B while respondents are required to assess the significance of the drivers of green procurement practices in Section C. A five-point Likert Scale was utilised in Sections B and C. Options such as "strongly disagree", "disagree", "neutral", "agree" and "strongly agree" were given to respondents for articulating their personal views. Moreover, Section D is designed to gather insights into the future outlook of green procurement practices in the Malaysian construction industry, emphasising future trends, innovation and potential opportunities. The response options varied according to the specific question. For Questions 1 and 3, respondents were asked to choose from "very unlikely", "unlikely", "neutral", "likely" and "very likely". For Question 2, options included "ahead of other countries", "on par with other countries" and "behind other countries". Question 4 offered the choices "very ineffective", "ineffective", "neutral", "effective" and "very effective". Question 5 provided "yes" or "no" while for Question 6, the options were "no impact", "minimal impact", "moderate impact" and "significant impact".

3.5.2 Pre-Test

Prior to the primary data collection, a pre-test of the questionnaire was carried out on a small sample of participants to ensure that the questionnaire meets the study objectives effectively. The purpose of the pre-test is to determine and rectify any issues with the terminology, phrasing, context and structure of the questionnaire. Participants were also prompted to provide comments on their understanding of the questions and the overall quality of the survey. Hence, the questionnaire is given to two clients, two consultants and two contractors to verify its appropriateness and comprehensibility. Any necessary modifications will be made prior to full distribution.

3.6 Data Analysis

The collected data from the questionnaire were systematically and comprehensively evaluated once the targeted respondents returned the questionnaires at the expected response rate. The collected data is analysed using several crucial methods that support the overall effectiveness and

reliability of the study. These include Shapiro-Wilk Test, Cronbach's Alpha Reliability Test, Mean Score and Standard Deviation, Kruskal-Wallis H Test, Spearman's Correlation Test as well as Factor Analysis.

The Statistical Package for Social Sciences (SPSS) was utilised to perform the aforementioned tests in order to produce trustworthy findings and insights. With the aid of SPSS, researchers may perform statistical data analysis, extract valuable insights from the analysed data and make well-informed conclusions from these data (Ong and Puteh, 2017).

3.6.1 Cronbach's Alpha Reliability Test

According to Saunders, Philip and Thornhill (2019), Cronbach's Alpha Reliability Test is a method for evaluating the internal consistency and reliability of questionnaire responses.

The alpha coefficient may range from 0 to 1. If the alpha coefficient is 0.7 or greater, it indicates that the questionnaire items are reliable as the scale's questions are internally consistent in evaluating the same underlying concept. However, an alpha coefficient that is closer to 0 denotes a lack of internal consistency because some or all of the elements measure different dimensions (Bujang, Omar and Baharum, 2018). Table 3.1 shows the rule of thumb for the results of Cronbach's alpha (Saidi and Siew, 2019).

Table 3.1: Rule of Thumb for Results of Cronbach's Alpha.

Source: Saidi and Siew, 2019.

Cronbach's Alpha	Internal Consistency
$\alpha \geq 0.900$	Excellent
$0.900 > \alpha \geq 0.800$	Good
$0.800 > \alpha \geq 0.700$	Acceptable
$0.700 > \alpha \geq 0.600$	Questionable
$0.600 > \alpha \geq 0.500$	Poor
$\alpha < 0.500$	Unacceptable

In this study, the data gathered using a Likert scale on green procurement practices implemented in the Malaysian construction industry as well as the perceived significance of the drivers for green procurement will be evaluated using the Cronbach's Alpha Reliability Test. An alpha value greater

than 0.70 is anticipated for each group of variables to show that the gathered data is consistent and reliable in representing the green procurement concept.

3.6.2 Normality Test – Shapiro-Wilk Test

Shapiro–Wilk test is employed to assess the normality of the collected data (Gonzalez-Estrada and Cosmes, 2019). The null hypothesis (H_0) asserts that the collected data is said to follow a normal distribution while the alternative hypothesis (H_1) contends that the data deviates from a normal distribution (Kwak and Park, 2019). This test is used to assess whether the collected data is normally distributed. This is because non-parametric tests such as the Kruskal-Wallis H test and Spearman's correlation test can only be applied if it is determined that the data is not normally distributed.

3.6.3 Mean Score and Standard Deviation

Mean score and standard deviation are widely used statistical approaches for ranking or prioritising variables based on their average scores. The mean is regarded as one of the most critical instruments for comparing variables since it demonstrates the data's central tendency. Meanwhile, to create a normally distributed statistical model, the standard deviation measures the variation within the data (Lee, In and Lee, 2015). After the computation of the mean value of each variable, these variables will be ranked in accordance with the determined mean. According to Yap, Low and Wang (2017), in cases where the means of two or more variables coincide, the variable with the smaller standard deviation is deemed highly significant.

A study conducted in Hong Kong utilised mean score ranking to discover the top five factors for green procurement in the country (Wong, Chan and Wadu, 2016). Similarly, a study in Malaysia employed both mean score and standard deviation approaches to evaluate the extent of readiness for implementing green procurement. The top three obstacles and top three drivers of implementing green procurement were also identified by this study (Razali et al., 2021).

In line with these approaches, the data collected from respondents on their agreement with green procurement practices implemented in the Malaysian construction industry as well as the significance of the drivers of

green procurement will be tested using mean score and standard deviation in this study. By utilising these statistical methods, the top five most significant practices and drivers can be identified based on their ranking.

3.6.4 Kruskal-Wallis H Test

The Kruskal-Wallis H test is a non-parametric statistical analysis used to compare more than two independent samples (Ostertagova, Ostertag and Kovac, 2014). In this study, this test will be applied to analyse the data gathered on green procurement practices and drivers in the Malaysian construction industry in order to compare the perspectives of clients, consultants and contractors. By utilising this test, significant differences between these three groups can be determined.

According to Nduka and Ogunsanmi (2015), a p-value greater than 0.05 suggests that there is no significant difference between the three respondent groups. Hence, the respondents share similar opinions regarding the questions in the questionnaire. On the other hand, a significant difference between the groups is shown if the p-value is equal to or less than 0.05, indicating that the respondent groups have different perceptions throughout the questionnaire.

3.6.5 Spearman’s Correlation Test

According to Schober and Schwarte (2018), Spearman's Correlation Test is a statistical instrument that assesses the strength and direction of a monotonic connection between two variables. This test can be applied to ordinal data, substantial outlier data, and continuous data that is not normally distributed. Spearman's correlation coefficient varies from -1 to +1 where a value nearer to 0 indicates a weaker linear relationship between the two variables. A correlation value of +1 denotes a perfect positive relationship, in which both variables rise or decrease simultaneously. However, a value of -1 implies a perfect negative relationship, in which one variable increases while the other decreases. The strength of the relationship between variables is shown in Table 3.2 (Yan et al., 2019; Ali Abd Al-Hameed, 2022).

Table 3.2: Strength of Relationship Between Variables.

Source: Yan et al., 2019.

Grading Standards	Correlation Degree
$r_s = 0$	No correlation
$0 < \| r_s \| \leq 0.19$	Very weak
$0.20 \leq \| r_s \| \leq 0.39$	Weak
$0.40 \leq \| r_s \| \leq 0.59$	Moderate
$0.60 \leq \| r_s \| \leq 0.79$	Strong
$0.80 \leq \| r_s \| \leq 1.00$	Very strong
1.00	Monotonic correlation

The Spearman's Correlation Test is employed in this study to evaluate the direction and degree of the relationship between the practices and drivers of green procurement. This test offers insights into how these variables are interrelated and helps determine which factors are most significant in supporting green procurement practices.

3.6.6 Factor Analysis

Factor Analysis is a statistical technique used to examine the underlying dimensions that explain the relationship between several variables, which helps to make a group of complicated variables easier to understand. Through the identification of these underlying factors, researchers can enhance the validity and precision of their measurements and offer higher-quality interpretations (Tavakol and Wetzel, 2020).

Before performing factor analysis, the suitability of the dataset must be evaluated. Firstly, the Kaiser-Meyer-Olkin (KMO) test is used to determine the appropriate sample size. Excellent sampling adequacy is achieved if the KMO values are between 0.80 and 1.00 while the range of 0.70 to 0.79 is regarded as moderate. Actions to improve the sampling are advised if the values fall between 0.60 and 0.69. However, values less than 0.50 imply that the data might not be appropriate for factor analysis. Moreover, the identity matrix of the correlation matrix is ascertained by applying Bartlett's Test of Sphericity. If the significance value is less than 0.05, factor analysis might be favourable to the data set; however, if the significance value is more than 0.05, factor analysis might not be suitable since the variables do not show strong enough correlations (Yap, Low and Wang, 2017; Shrestha, 2021).

Exploratory factor analysis (EFA) was used in a Malaysian study to determine the five main underlying factors contributing to the obstacles to green procurement practices (Yap et al., 2024a). Similarly, this study employs EFA to investigate the principal factors of green procurement practices and analyse the interrelationships between the 21 drivers of green procurement in construction projects. According to Shrestha (2021) and Williams, Onsman and Brown (2010), prior to performing the factor analysis, it is crucial to ensure that the KMO value is larger than 0.50 and that Bartlett's test has a significant value less than 0.05. Moreover, Kaiser's criterion, which is used to select the number of factors to be extracted, suggests that only factors with an eigenvalue greater than 1.00 should be retained since they explain more variation than any one original variable. Besides, in order to provide a clearer interpretation of the results, varimax orthogonal rotation is used to reduce the number of variables with large loadings on numerous factors. In addition to that, a minimum of 60% cumulative variance should be attained in order to demonstrate construct validity and guarantee that the factors are not the result of random changes. Finally, the principal groupings of the 21 drivers of green procurement can be investigated when the factor analysis is completed.

3.7 Summary

To conclude, a structured overview of the execution of the study was provided, including every phase from the first data gathering phases to the latter data analysis procedures. The convenience and snowball sampling techniques are employed for participant selection. A quantitative approach was utilised to achieve the research objectives. A questionnaire survey was used for the data collection and the questionnaires were sent to the intended respondents with the target of receiving at least 110 responses. A pre-test is carried out before questionnaire distribution to ensure the questionnaire is appropriately constructed and meets the study's objectives. The targeted respondents were the clients, consultants and contractors in Klang Valley. Furthermore, as shown in Figure 3.3, six data analysis methods were utilised in this chapter to interpret the data efficiently: "Shapiro-Wilk Test" to determine the normality of the dataset, "Cronbach's Alpha Reliability Test" to evaluate reliability, "Mean Score and Standard Deviation" to identify the top five most significant practices

and drivers, “Kruskal-Wallis H Test” to compare the viewpoints between clients, consultants and contractors, “Spearman’s Correlation Test” to ascertain the relationship between practices and drivers as well as “Factor Analysis” to investigate the principal factors of green procurement practices.

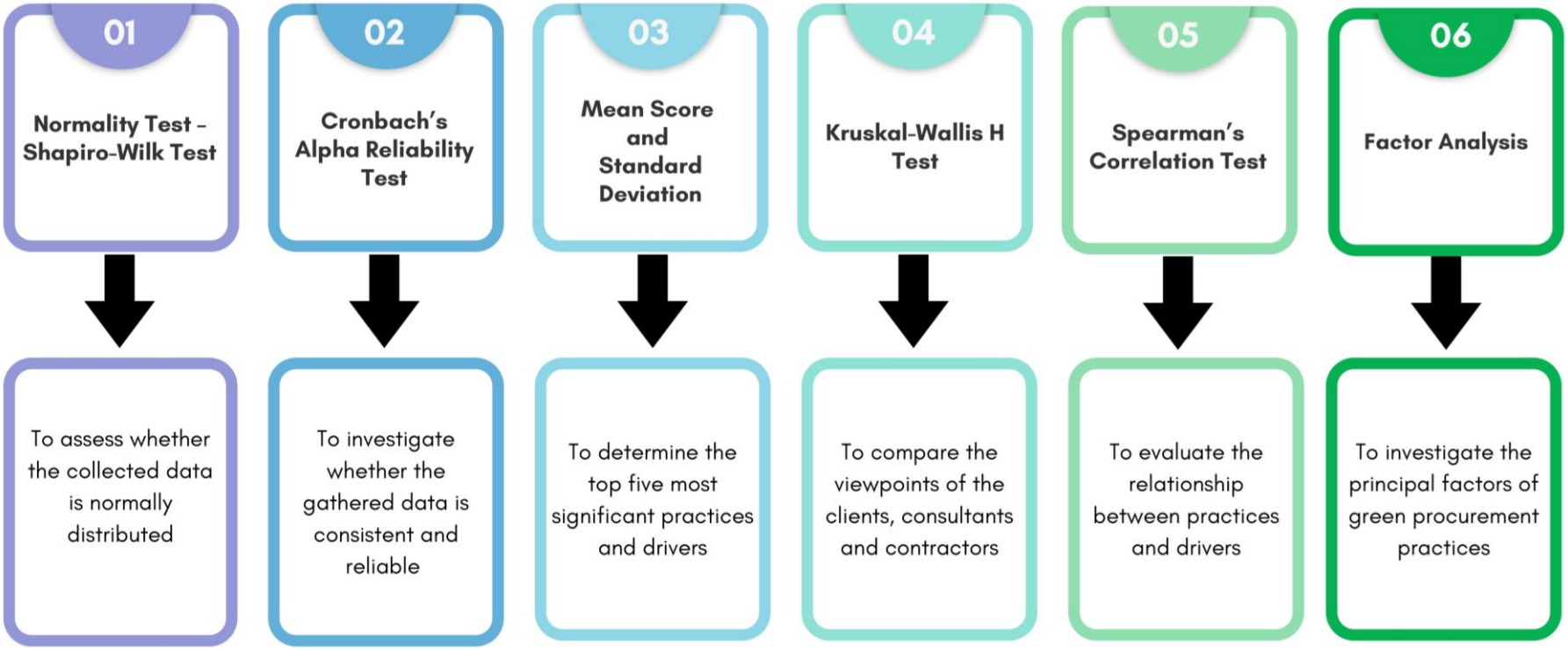

Figure 3.3: Summary of Data Analysis Methods.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the questionnaire survey. The Statistical Package for the Social Sciences (SPSS) and Microsoft Excel were used to organise, process and tabulate the collected data. The analysis and discussion presented are structured to directly address the aims and objectives of the study.

4.2 Pre-Test

In this study, the pre-test survey achieved a 100% response rate, with participation from two clients, two consultants and two contractors. This comprehensive response enhances the reliability of the findings by ensuring that representatives from all participant categories were included. Feedback was collected on the clarity, structure and relevance of the questionnaire. Any identified issues, such as ambiguous wording or potential misinterpretation of specific terms, were meticulously modified through revisions before the pilot test.

4.3 Pilot Study

Prior to the distribution of the remaining questionnaires, a pilot test was carried out to evaluate the validity and reliability of the survey instrument. The pilot test sample size was determined based on the Central Limit Theorem (CLT), which states that a sample of 30 or more is adequate for ensuring reasonable accuracy (Chihara and Hesterberg, 2018). As a result, a total of 35 questionnaires were initially distributed to construction practitioners via emails and social media platforms, of which 30 were successfully returned, resulting in a response rate of approximately 86%.

To evaluate the reliability of the collected data, Cronbach's Alpha Reliability Test was performed, and the alpha coefficient corresponding to each division of the questionnaire survey was recorded in Table 4.1. The table shows that all questionnaire sections demonstrated strong internal consistency with an alpha coefficient above the threshold value of 0.70 (Yap and Lee, 2020). This

indicates that the collected data was considered both reliable and acceptable. Since the instrument was deemed reliable and required no further modifications, all 30 responses from the pilot study were incorporated into the main study.

Table 4.1: Cronbach's Coefficients Obtained from the pilot study.

Category of variables	No. of items	Cronbach's alpha
Green Procurement Practices	15	0.806
Drivers of Green Procurement Practices	21	0.901

4.4 Response Rate

The positive outcomes from the pre-test led to the distribution of the final questionnaire to the targeted respondents through email and a variety of social media platforms, such as WhatsApp, LinkedIn and Instagram in order to maximise outreach across organisations. A total of 250 questionnaires were distributed to key stakeholders in the Klang Valley region. Over the course of five weeks, 140 completed and valid responses were collected, resulting in a response rate of 56%. Since it exceeds the minimal threshold of 30%, it is considered adequate to ensure the reliability of the findings in relation to the number of free parameters, thereby supporting meaningful statistical analysis (Yap et al., 2020).

4.5 Respondent's Profile

The profile of the respondents is presented in Table 4.2. The majority of respondents were consultants (36.4%), followed by developers (32.9%) and contractors (30.7%). Regarding work experience, a significant proportion (57.9%) had less than five years of experience in the construction sector. Meanwhile, 42.1% of the respondents had at least six years of experience, with 17.1% categorised as experts, as they possess 11 or more years of industry experience. Furthermore, the vast majority of respondents (66.4%) were executives in their companies, whilst 17.9% and 9.3% were managers and senior managers, respectively. However, obtaining responses from top management and director-level individuals proved challenging, as they constituted only 6.4% of the respondents. Moreover, the tables also indicate that most respondents

(83.6%) worked primarily on private projects, while only 16.4% mainly participated in public projects.

Table 4.2: Demographic Profile of Respondents.

Parameter	Categories	Frequency	Percentage (%)
Nature of Organisation	Developer	46	32.9
	Consultant	51	36.4
	Contractor	43	30.7
Working Experience	Less than 5 years	81	57.9
	5 – 10 years	35	25.0
	11 – 15 years	11	7.9
	16 – 20 years	8	5.7
	> 20 years	5	3.6
Position in Company	Executive	93	66.4
	Manager	25	17.9
	Senior Manager	13	9.3
	Top Management / Director	9	6.4
Type of Project	Private Project	117	83.6
	Public Project	23	16.4

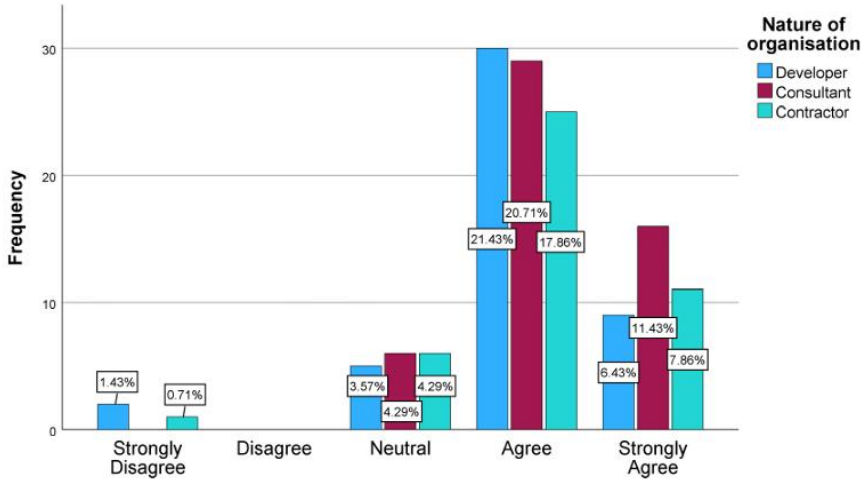

Figure 4.1: Necessity of Green Procurement for a Sustainable Construction Industry.

Figure 4.1 illustrates the varying perceptions of respondents regarding the necessity of green procurement for a sustainable construction industry. 85.7% of respondents agreed that green procurement is essential for sustainability in the construction industry, while 12.2% remained neutral and 2.1% disagreed.

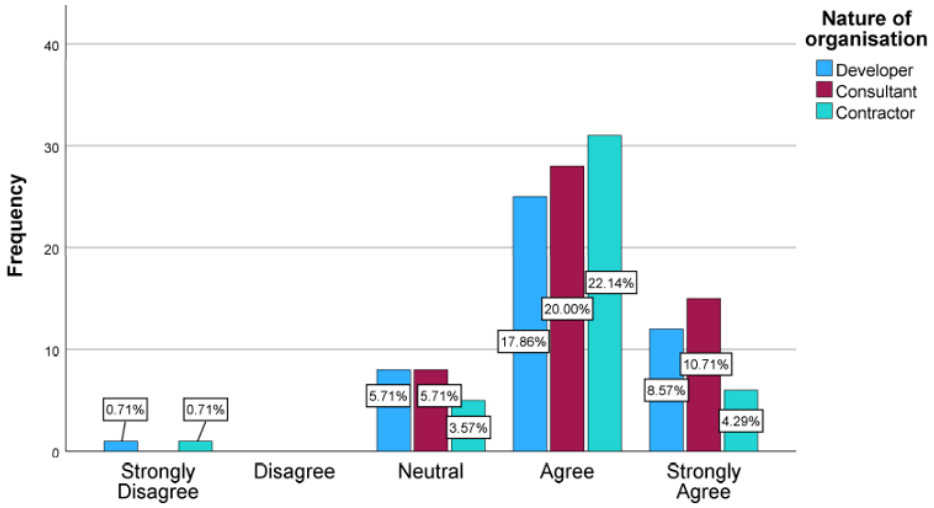

Figure 4.2: Urgency of Green Procurement Adoption in the Malaysian Construction Industry.

Figure 4.2 shows the varying perceptions of respondents regarding the urgency of green procurement adoption in the Malaysian construction industry. 83.6% of respondents believe that adopting green procurement is crucial for the Malaysian construction industry, while 15.0% held a neutral stance and 1.4% disagreed.

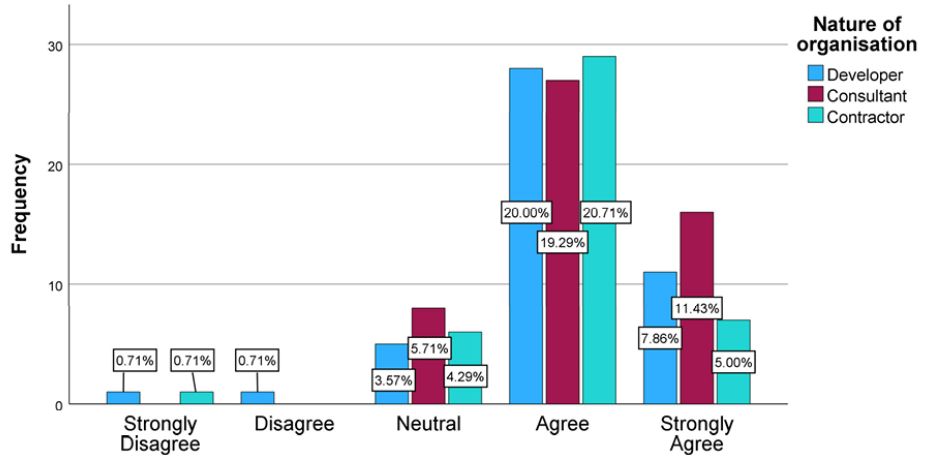

Figure 4.3: Importance of Understanding Green Procurement for Sustainable Development in Malaysian Construction Industry.

Figure 4.3 illustrates respondents' perceptions of the importance of understanding green procurement for sustainable development in the Malaysian construction industry. A vast majority (84.3%) agreed that such knowledge is crucial, while 13.6% remained neutral, and 2.1% disagreed.

4.6 Cronbach's Alpha Reliability Test

A Cronbach's Alpha Reliability Test is conducted to evaluate the consistency and reliability of the collected data. As shown in Table 4.3, the alpha values for each variable surpassed the threshold of 0.70, indicating strong internal consistency. According to the Saidi and Siew (2019), a Cronbach's alpha value between 0.8 and 0.9 is generally considered to indicate good internal consistency, while a value greater than 0.9 is regarded as reflecting excellent internal consistency. Thus, the collected data is deemed to exhibit good to excellent reliability.

Table 4.3: Summary of Reliability Analysis.

Category of Variables	Number of Items	Alpha Value
Green Procurement Practices	15	0.876
Drivers of Green Procurement Practices	21	0.927

4.7 Normality Test – Shapiro-Wilk Test

Normality test is used to assess whether the collected data is normally distributed. In this study, SPSS analysis yielded a p-value of less than 0.001 for both green procurement practices and drivers, indicating a significant deviation from normality. The null hypothesis (H_0) was rejected in favour of the alternative hypothesis (H_1) (Kwak and Park, 2019). Consequently, non-parametric tests, such as the Kruskal-Wallis H test and Spearman's correlation test, are appropriate for further analysis.

4.8 Green Procurement Practices

4.8.1 Future Outlook for Green Procurement Practices in the Malaysian Construction Industry

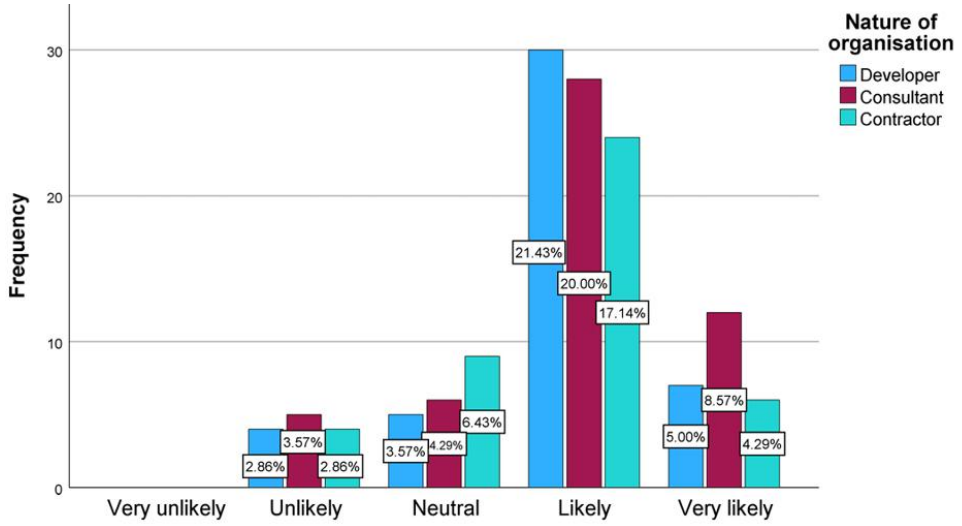

Figure 4.4: Expected Adoption of Green Procurement in the Malaysian Construction Industry Over the Next Five Years.

Figure 4.4 presents respondents' perceptions of the likelihood of adopting green procurement practices in the Malaysian construction industry within the next five years. The results show that a significant portion of respondents believe adoption is likely, with 21.4% of developers, 20.0% of consultants, and 17.1% of contractors indicating this view. A smaller but notable proportion perceived adoption as very likely, particularly consultants (8.6%), followed by developers (5.0%) and contractors (4.3%). Nevertheless, neutral responses remained relatively low, with 6.4% of contractors, 4.3% of consultants, and 3.6% of developers expressing uncertainty. Less than 4% of each group believed adoption was unlikely or very unlikely.

Overall, developers and consultants exhibited greater optimism regarding the future adoption of green procurement compared to contractors. As primary project initiators, developers often take the lead in securing environmental approvals and advancing corporate social responsibility commitments, particularly in urban developments. Moreover, the rising demand for green-certified buildings in Malaysia has further incentivised developers to embrace sustainable practices as a market differentiator. On the other hand,

consultants often serve as technical advisors and design professionals. Their expertise in aligning design and technical aspects with sustainability standards positions them as strong advocates for green procurement. Their optimism may also reflect their professional alignment with international best practices and evolving regulatory expectations. In contrast, contractors expressed comparatively moderate confidence, which may be attributed to practical concerns such as cost implications, procurement complexities and implementation challenges on-site. Due to their responsibility for project execution within strict budget and time constraints, contractors may be less inclined to adopt green procurement practices unless driven by client mandates or regulatory enforcement (Ferreira, Morgado and Lins, 2024).

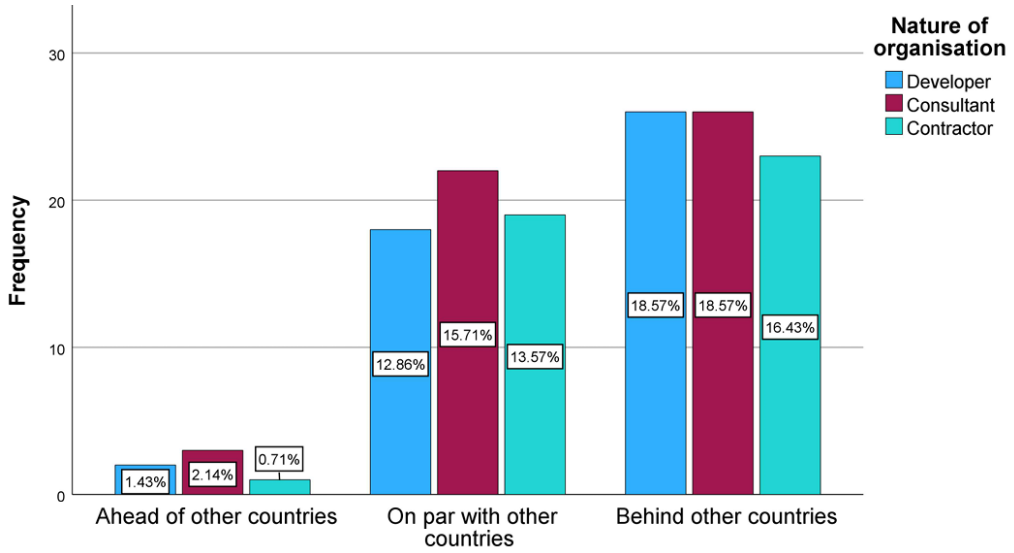

Figure 4.5: Perception of Malaysia's Green Procurement Progress in Comparison to Other Countries.

Figure 4.5 illustrates respondents' perceptions regarding Malaysia's progress in green procurement compared to other countries. The majority view the green procurement progress of the nation as lagging behind that of other countries, with 18.6% of both developers and consultants and 16.4% of contractors expressing this perspective. In comparison, a moderate proportion of respondents believe Malaysia is on par with international standards, comprising 15.7% of consultants, 13.6% of contractors and 12.9% of developers. This suggests that while some stakeholders recognise incremental progress, the

perception of Malaysia keeping pace with global green procurement trends remains limited. On the contrary, only a small minority of respondents considered Malaysia to be ahead in green procurement practices. This includes 2.1% of consultants, 1.4% of developers and 0.7% of contractors.

Several factors may account for these perceptions. Firstly, the relatively slow implementation of comprehensive green procurement policies and the lack of robust regulatory enforcement in Malaysia likely contribute to the view that the country is falling behind. In contrast to developed nations where sustainability regulations are stringent and consistently applied, Malaysia's green procurement efforts have often been criticised for being voluntary, fragmented and inconsistently enforced. Moreover, high initial cost and limited financial incentives serve as substantial barriers to adoption, further reinforcing the perception of insufficient progress. In addition, a lack of awareness and technical expertise among industry stakeholders, particularly within small and medium-sized enterprises (SMEs), further undermines industry confidence in Malaysia's ability to align with global sustainability standards (Ogunsanya et al., 2022; Yap et al., 2024a). Contractors, who are directly responsible for project execution and typically prioritise cost efficiency, may be especially affected by these challenges, making them less likely to perceive Malaysia as a frontrunner in green procurement practices.

4.8.2 Mean Score and Standard Deviation

The adoption of green procurement practices in the construction industry is ranked in accordance with the mean and standard deviation computed as shown in Table 4.4. Overall, the five most critical adoption of green procurement practices are:

(i) E-procurement (Mean = 4.21; $\delta = 0.676$)

(ii) Procuring non-toxic and low Volatile Organic Compounds (VOCs) materials (Mean = 4.16; $\delta = 0.745$)

(iii) Waste management and recycling (Mean = 4.16; $\delta = 0.764$)

(iv) Purchasing green products and services (Mean = 4.14; $\delta = 0.670$)

(v) Giving preference to certified products (Mean = 4.14; $\delta = 0.691$)

E-procurement is being ranked as the most widely adopted green procurement practice in this study. This finding aligns with the past study of Opoku et al. (2022), who highlighted that e-catalogues, e-ordering, e-sourcing and e-tendering have already been increasingly developed and widely integrated into procurement activities in the construction industry. Similarly, Wimalasena and Gunatilake (2018) emphasise that e-procurement reduces reliance on paper products and lowers the overall carbon footprint. E-procurement systems also promote sustainable procurement by facilitating the identification and acquisition of environmentally friendly products and services (Singh et al., 2020). In addition, Ibem and Laryea (2015) underscore that the widespread adoption of e-procurement is primarily due to its efficiency, lower transaction costs and ease of use. The automation of procurement processes through e-procurement reduces human intervention, facilitating faster data transmission and minimising delays. Furthermore, by reducing the need for physical document handling, e-procurement lowers transaction costs associated with transportation. The ability to electronically transmit, approve and manage procurement documents also eliminates the necessity for excessive paperwork, ultimately enhancing operational efficiency and supporting sustainability goals.

The second most widely adopted green procurement practice ranked by the respondents is “procuring non-toxic and low Volatile Organic Compounds (VOCs) materials”. According to Shah and Li (2019), enhancing indoor environmental quality is crucial as people spend the majority of their time indoors. Poor indoor air quality can significantly affect the health and well-being of building occupants. Liang (2020) further underscores that construction workers are particularly vulnerable to VOC exposure, especially during interior finishing work in construction buildings. As a result, non-toxic or low-VOC materials are widely adopted to mitigate these health risks. Moreover, Malik and Sarkhel (2024) as well as Pawar and Mahanwar (2023) highlight that low-VOC and water-based coatings contain fewer VOCs compared to traditional paints, as they are formulated with water or other environmentally safe solvents. This leads to lower emissions of harmful substances during both application and curing. Consequently, reducing VOC emissions enhances indoor air quality and helps prevent the formation of ground-level ozone, which is associated with respiratory issues and other health concerns. The preference for these materials

reflects a heightened awareness of the health risks associated with VOC exposure, such as respiratory problems and other adverse health effects.

Next, waste management and recycling emerged as the third most widely adopted green procurement practice. As aforesaid, the construction industry is a major contributor to waste generation globally, with common waste materials including concrete, ceramics, mortar, masonry, steel and plastic packaging. Effective waste management not only reduces the volume of waste and landfill disposal costs but also helps mitigate environmental degradation while providing substantial economic benefits (Jin et al., 2017; Opoku et al., 2022). Reducing landfilling conserves valuable landfill capacity in addition to lowering the production of harmful gases, such as carbon dioxide and methane, and leachate from the anaerobic degradation of waste (Lu et al., 2019). According to Umar, Shafiq and Ahmad (2021), waste management can be achieved through several strategies, such as the reuse or recycling of packaging materials and the use of recycled materials. Such strategies are not only environmentally beneficial but also cost-effective, as they reduce the need for virgin materials and contribute to the circular economy. Furthermore, carefully evaluating material requirements to prevent over-ordering at construction sites helps minimise waste caused by improper storage or damage. In other words, waste management and recycling help align with both economic and environmental objectives within the construction industry.

Moreover, “purchasing green products and services” is ranked as the fourth most significant practice in the construction industry. This aligns with previous studies by Eze et al. (2021), which highlight the substantial benefits of incorporating green products and services into construction. These benefits include long-term savings in lifecycle costs, improved energy efficiency, enhanced productivity and a reduced environmental footprint. Although these green products and services may have higher initial costs, they often lead to long-term savings by improving energy efficiency and reducing operational expenses. Additionally, sustainable materials such as steel slag can be incorporated into asphalt mixtures and demonstrate higher stability and reduced rutting. This further emphasises the potential of sustainable materials to improve both the performance and environmental impact of construction projects (Kumar and Shukla, 2023). Furthermore, the significance of selecting materials

that align with the Green Building Index (GBI) cannot be overstated. According to Bohari et al. (2017), GBI tools serve as essential guides for project teams in their pursuit of green initiatives. These tools provide a structured framework for assessing materials, offering clear benchmark criteria to facilitate effective evaluation and scoring. By adhering to GBI standards, construction projects ensure that the materials used are not only sustainable but also environmentally responsible, contributing to the overall success of green building efforts.

Last but not least, "giving preference to certified products" ranks as the fifth most significant green procurement practice. By prioritising the certified products, construction firms can demonstrate their commitment to environmental responsibility as these certifications serve as evidence that the materials meet established sustainability criteria established by relevant recognised authorities (Opoku and Fortune, 2014). This finding is further supported by a study conducted by Yousif, Misnan and Ismail (2023) which highlights that the eco-labelling details the manufacturers' approach to addressing the environmental impact of the products, thereby providing valuable guidance to construction stakeholders in selecting the most appropriate green products and services for their projects. Moreover, the use of certified and eco-labelled products helps mitigate the possibility of reputational damage and regulatory non-compliance that can arise from greenwashing, the unethical practice of making misleading or unsubstantiated environmental claims about a product's attributes (Oguntona and Aigbavboa, 2019). Furthermore, a previous study by Yuan (2023) emphasises that selecting eco-labelled products can improve indoor air quality and foster a better interior environment during manufacturing and consumption. The emphasis on eco-labelling suggests that construction stakeholders are increasingly prioritising products with verified environmental benefits, indicating a shift towards more informed and responsible procurement decisions.

Table 4.4: Mean Score and Standard Deviation of Green Procurement Practices.

Ref	Practices	Overall (N=140)			Developer (N=46)			Consultant (N=51)			Contractor (N=43)			Chi-square	Asymp. sig
		Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R		
	Conventional green procurement practices														
P1	Qualification of stakeholders based on knowledge and experience	4.05	0.723	11	3.98	0.830	13	4.02	0.648	11	4.16	0.688	4	1.238	0.538
P2	Opting for products with minimal or eco-friendly packaging	4.03	0.749	13	4.00	0.667	10	4.08	0.796	10	4.00	0.787	12	0.585	0.747
P3	Procuring non-toxic and low-VOC materials	4.16	0.745	2	4.20	0.719	4	4.16	0.731	4	4.14	0.804	6	0.078	0.962
P4	Giving preference to certified products	4.14	0.691	5	4.02	0.774	8	4.20	0.633	1	4.19	0.664	2	1.102	0.576
P5	Adoption of local suppliers	4.05	0.713	10	4.02	0.774	8	4.10	0.700	7	4.02	0.672	10	0.420	0.811
P6	Purchasing green products and services	4.14	0.670	4	4.30	0.662	2	4.16	0.674	3	3.93	0.632	14	7.032	0.030*
P7	Incorporation of green specifications into the contract	4.11	0.765	8	4.13	0.687	6	4.16	0.758	6	4.02	0.859	11	0.701	0.704
P8	Purchase value of money	3.86	0.807	15	3.89	0.875	14	3.82	0.793	15	3.88	0.762	15	0.399	0.819
P9	Adoption of energy-efficient machinery and equipment	4.04	0.868	12	4.00	1.033	12	4.02	0.787	13	4.09	0.781	8	0.157	0.925
P10	Waste management and recycling	4.16	0.764	3	4.22	0.696	3	4.20	0.775	2	4.07	0.828	9	0.881	0.644
	Innovative green procurement practices														
P11	E-procurement	4.21	0.676	1	4.46	0.504	1	4.02	0.707	12	4.19	0.732	3	9.208	0.010**
P12	Prefabrication and modular construction	3.94	0.803	14	3.89	0.948	15	3.98	0.707	14	3.95	0.754	13	0.070	0.966
P13	Utilising renewable energy sources or technology	4.09	0.767	9	4.00	0.789	11	4.16	0.731	4	4.12	0.793	7	0.890	0.641
P14	Integration of Building Information Modeling (BIM) for sustainability	4.14	0.751	6	4.15	0.698	5	4.10	0.728	8	4.16	0.843	5	0.360	0.835

P15	Procuring green building technologies	4.12	0.714	7	4.04	0.698	7	4.08	0.771	9	4.26	0.658	1	2.080	0.353

N = Sample size, SD = Standard Deviation.

Note:

**. The mean difference is statistically significant at the 0.01 level ($p < 0.01$).

*. The mean difference is statistically significant at the 0.05 level ($p < 0.05$).

4.8.3 Kruskal-Wallis H Test

The Kruskal-Wallis H test is conducted to examine differences in perceptions of green procurement practices among clients, consultants and contractors. Table 4.4 shows that there are statistically significant differences between "purchasing green products and services" and "e-procurement" among the 15 green procurement practices.

First and foremost, the table shows that the mean score of the developer (mean = 4.30) is found to be comparatively high in comparison to the mean scores of the other two categories of respondents. This indicates that developers place greater emphasis on purchasing green products and services compared to consultants and contractors. According to Yang et al. (2019), developers significantly influence the green procurement decision-making across the entire lifecycle of a construction project. Their strategic involvement makes it possible to incorporate sustainability principles into various aspects of the procurement process, from fostering a culture of environmental responsibility within the organisation to making informed choices in the selection of green products and services. Moreover, developers are often motivated by the potential benefits that green procurement practices can bring to an organisation's image and market competitiveness. These incentives encourage developers to embrace and implement green procurement practices compared to other stakeholders who might not have as much control over such strategic decisions. Furthermore, Yuan (2023) underscores that the adoption of sustainable materials consumes less energy and has minimal environmental impact, further reinforcing the developers' commitment to environmental responsibility.

In addition, developers prioritise e-procurement compared to consultants and contractors. This finding aligns with the study of Affendy et al. (2022), which highlights that e-tendering systems significantly reduce the time required for tendering processes while also improving transparency compared to conventional procurement methods. These systems enable developers to quickly obtain comprehensive information on bids and tenderers, thereby facilitating more informed and strategic decision-making. From a developer's perspective, e-procurement contributes to cost-efficiency and expedites project delivery schedules, which is in line with their broader project management and financial objectives. Conversely, consultants place comparatively less

importance on e-procurement, as reflected by its ranking of 12th among 15 green procurement practices. According to Aziz (2024), employees within organisations frequently show reluctance to implement e-tendering systems because they are accustomed to using conventional techniques and are unsure about digital procedures. This resistance is particularly evident among consultants, who could be more used to conventional procurement practices.

4.9 Drivers of Green Procurement Practices

4.9.1 Future Outlook on the Drivers of Green Procurement Practices in the Malaysian Construction Industry

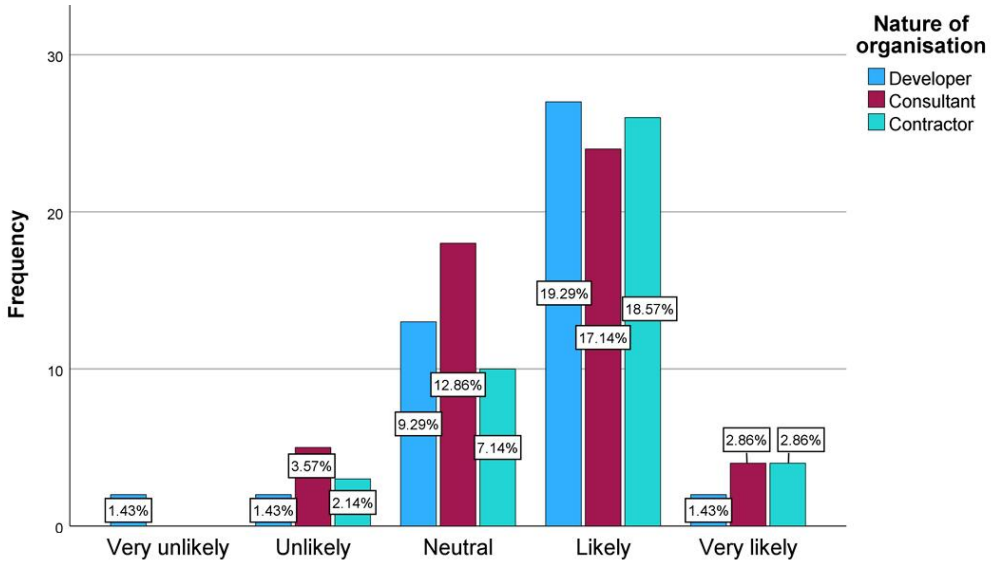

Figure 4.6: Likelihood of Organisations Allocating More Resources to Green Procurement Initiatives in the Next Five Years.

Figure 4.6 illustrates a strong overall expectation of increased investment in green procurement initiatives within the Malaysian construction industry over the next five years. A significant proportion of respondents anticipated that their organisations are likely to enhance their commitment to green procurement, including 19.3% of developers, 18.6% of contractors and 17.1% of consultants. Furthermore, a smaller yet notable proportion of respondents perceive such investment as very likely, including 2.9% of both consultants and contractors, and 1.4% of developers. This reflects a growing recognition of the importance of sustainability and a shift in organisational priorities toward more environmentally responsible procurement practices.

Neutral responses were particularly notable among consultants (12.9%), developers (9.3%) and contractors (7.1%), suggesting that although optimism is generally widespread, some professionals remain uncertain about the extent of future organisational commitment to green procurement. On the contrary, the percentage of respondents indicating unlikely or very unlikely was minimal across all groups, with percentages not exceeding 3.6%. This low level of pessimism reinforces an overall positive outlook toward advancing green procurement in the industry.

Overall, developers and contractors appear to hold a more optimistic view toward increased investment in green procurement initiatives compared to consultants. This positive outlook is largely driven by the recognition of both financial and environmental benefits associated with sustainable practices. According to Wong, Chan and Wadu (2016), cost savings and waste reduction can significantly influence corporate decisions to adopt green procurement practices. In particular, contractors are likely motivated by the increasing availability of advanced energy-efficient machinery, such as electric hybrid and pure electric systems, which enhance operational efficiency and reduce long-term costs (Lin et al., 2020). For instance, Huang et al. (2023) underscore that the adoption of electric wheel loaders and dump trucks led to a reduction in energy consumption per operational cycle by 1.55% and 5.69%, respectively, along with a 2.61% decrease in daily operational costs. These tangible gains strengthen the economic rationale for contractors to invest in green technologies.

Meanwhile, developers showed the lowest percentage in the "very likely" category although they expressed great optimism in the “likely” category. This suggests a more cautious stance toward high-certainty commitments in future green investments. Such caution may stem from uncertainties surrounding market demand for green buildings, fluctuating economic conditions or dependence on government incentives that have not yet matured. Since developers often weigh environmental goals against financial returns, they may anticipate increased investment but adopt a measured approach regarding its scope and timing (Onubi, Yusof and Hassan, 2020).

In contrast, the consultants exhibited more moderate optimism than developers and contractors. This perspective is likely influenced by their technical expertise and in-depth understanding of both the opportunities and the

implementation challenges inherent in sustainable practices. Consultants frequently encounter two critical barriers, which are the absence of strong governance frameworks and the widespread perception of high upfront costs associated with sustainable solutions (Ogunsanya et al., 2022). These factors, coupled with changing industry standards and the complexities of integrating sustainability into diverse project contexts, contribute to a more cautious and measured outlook. Additionally, while consultants recognise the long-term benefits of sustainable procurement, they are also aware that such perspectives are not always shared by all stakeholders, particularly when immediate costs are a concern. Their neutrality reflects a realistic assessment of the systemic and operational challenges that must be addressed for widespread adoption.

Bridging these varying outlooks, it is evident that growing awareness of the long-term benefits of sustainable practices is encouraging organisations to embed green procurement within their corporate culture. Bohari et al. (2017) further underscore that project teams are more committed to achieving the best possible green performance in construction activities when sustainability is ingrained as a core value. Thus, the respondents' anticipation of increased resource allocation may reflect a growing internalisation of sustainability values and a strategic response to the long-term advantages of green procurement.

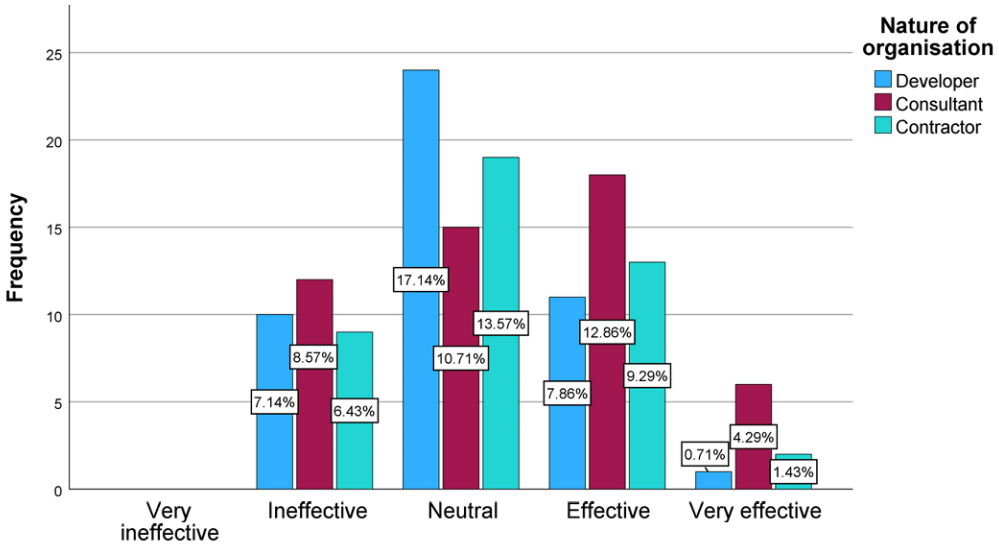

Figure 4.7: Effectiveness of Government Policies in Promoting Green Procurement Practices in the Malaysian Construction Industry.

Figure 4.7 illustrates that the effectiveness of government policies in promoting green procurement practices in the Malaysian construction industry reveals a mixed perception among respondents. Government policies were viewed favourably by a comparatively small percentage of respondents. This includes 7.9% of developers, 12.9% of consultants and 9.3% of contractors. Meanwhile, fewer respondents rated the policies as highly effective, with only 0.7% of developers, 4.3% of consultants and 1.4% of contractors expressing this sentiment.

A significant portion of respondents, particularly developers (17.1%), contractors (13.6%) and consultants (10.7%), remained neutral on the effectiveness of government policies. This indicates a degree of uncertainty or ambiguity regarding the tangible outcomes of existing policies. Moreover, the data also shows that a moderate percentage of respondents considered government policies ineffective, with 7.1% of developers, 8.6% of consultants and 6.4% of contractors sharing this view. Notably, none of the respondents consider the policies to be very ineffective, indicating that although there is some dissatisfaction exists, the perception of complete ineffectiveness is not prevalent.

Overall, the neutral perception of the effectiveness of current government policies in promoting green procurement in Malaysia can be attributed to several key limitations. One significant issue is the restricted scope and application of the Government Green Procurement (GGP) guidelines. According to Razali et al. (2021), the GGP guidelines are largely limited to government projects and have yet to be fully integrated across the broader construction industry, particularly within private sector developments. This narrow focus restricts the influence of GGP policies, limiting their ability to drive widespread adoption of sustainable procurement practices.

Similarly, a study conducted by Anuar, Khalil and Bohari (2021) highlights that the GGP guidelines, first introduced in 2014 and updated in 2018, primarily target general government products and services, rather than addressing the specific needs of the construction sector. This limited scope diminishes the applicability and perceived effectiveness of these policies among construction stakeholders, contributing to uncertainty or ambivalence regarding their effectiveness. The study further identifies essential criteria for successfully

implementing green procurement throughout the construction project lifecycle. During the inception phase, key considerations include ensuring that appointed consultants possess adequate green knowledge, incorporating green rating tools as part of the project planning as well as ensuring environmental and energy efficiency requirements are clearly articulated in the project brief. Moving into the design stage, priority should be given to conducting green cost analyses and feasibility studies, mandating the compliance with Malaysian Standards MS1525 and undertaking carbon emission calculations.

Furthermore, the absence of mandatory legislation enforcing green procurement practices presents a major barrier to broader adoption. In the absence of legal requirements, industry participation remains largely voluntary, leading to inconsistent and uneven implementation across the sector. This challenge is further exacerbated by the lack of robust enforcement and monitoring mechanisms, which undermine compliance with the existing guidelines. Such insufficient oversight leads to limited accountability and transparency, making it difficult to assess the actual impact of government policies (Alqadami et al., 2020a). Therefore, these limitations reinforce the perception that current government policy efforts lack the authority, coherence and enforcement capacity necessary to drive meaningful and lasting change.

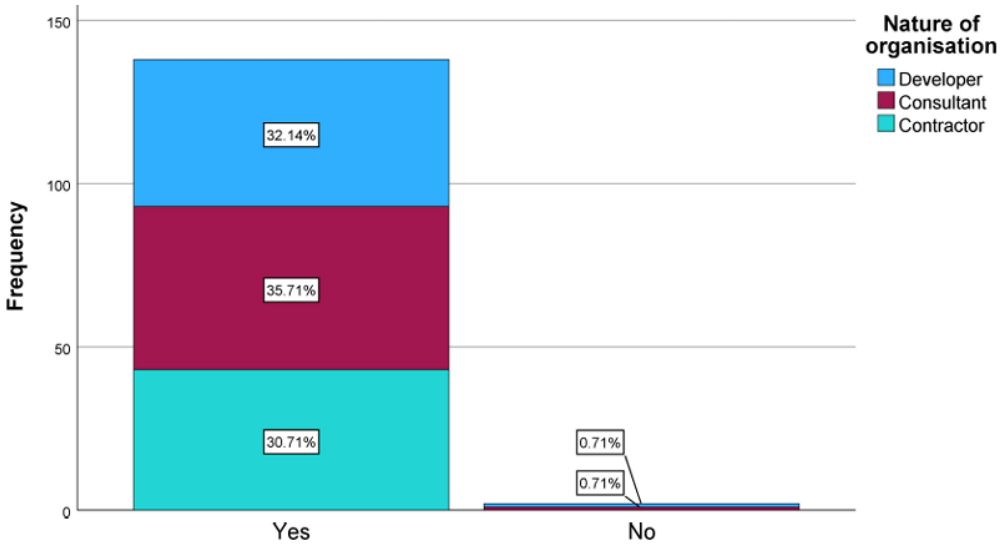

Figure 4.8: Perceived Need for Training and Resources to Support Green Procurement Practices.

Based on Figure 4.8, there is a strong consensus among respondents regarding the need for additional training and resources to promote green procurement practices. The vast majority of respondents agreed with this need, including 35.7% of consultants, 32.1% of developers and 30.7% of contractors. In contrast, only a negligible proportion of respondents expressed disagreement, with 0.71% each of developers and consultants and none of the contractors indicating that training and resources were unnecessary.

This finding aligns with the previous studies of Razali et al. (2021) and Masyhur et al. (2024) which emphasises the need for public and private organisations to offer targeted campaigns and workshops in order to raise awareness and competency in sustainable procurement. Through campaigns and workshops, construction stakeholders can gain knowledge about environmental issues, the importance of the sustainable development movement and government support as well as the disadvantages of high pollution and carbon emissions in the environment. Thus, there is a necessity for well-structured and easily accessible educational platforms that can bridge existing knowledge gaps and facilitate the successful adoption of green procurement.

Moreover, Hinterhuber and Khan (2025) highlight that organisations can integrate training or workshops into employee development programmes through activities such as carbon footprint audits of procurement practices, environmental impact simulations and storytelling initiatives that illustrate the positive outcomes of sustainable decisions. During such training sessions, employees can be exposed to examples of procuring environmentally friendly products and materials, helping them understand how these choices contribute to resource conservation, carbon emissions reduction and overall environmental improvement. These practical learning experiences can enhance construction professionals' understanding and appreciation of the long-term advantages as well as the strategic importance of adopting green procurement practices. As green technologies and sustainable materials continue to evolve at a rapid pace, ongoing training is essential for construction professionals to stay abreast of industry advancements. Continuous education equips stakeholders with the knowledge required to make informed and up-to-date procurement decisions that align with sustainability goals. For developers, such training enhances their understanding of the long-term financial advantages of investing in sustainable

materials and green building technologies beyond initial capital costs. Consultants are better equipped to propose environmentally responsible alternatives that align with project objectives while achieving cost-effective outcomes. Meanwhile, contractors benefit from acquiring the technical expertise required to effectively install and manage green technologies and materials on-site, thereby minimising construction errors and reducing material waste.

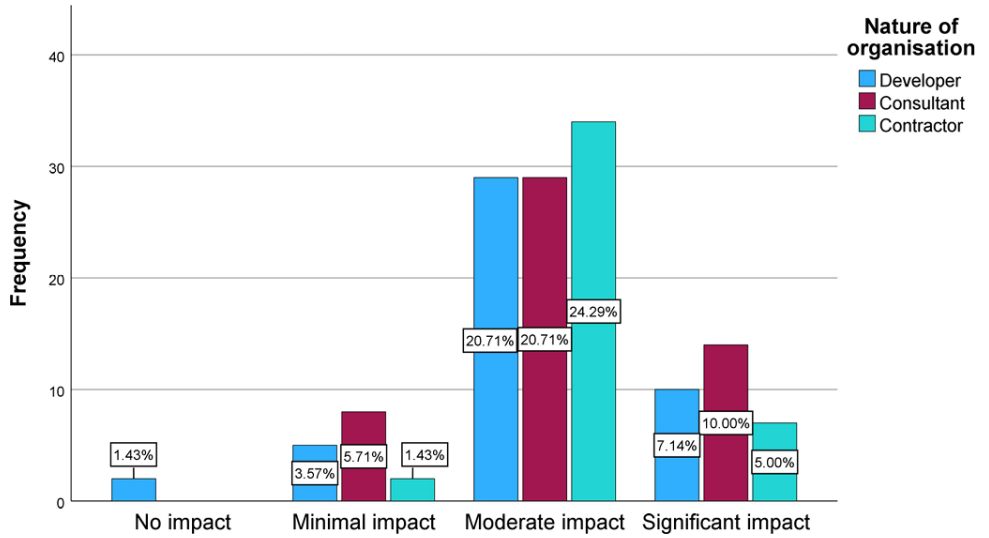

Figure 4.9: Perceived Impact of Consumer Demand on Green Procurement in the Construction Industry.

As shown in Figure 4.9, the majority of respondents perceived consumer demand to have a moderate impact on green procurement in the construction industry. In particular, moderate impact was recognised by 20.7% of developers and consultants and 24.3% of contractors, suggesting that consumer preferences are becoming more widely acknowledged as a determining factor in procurement decisions. A smaller but notable percentage of respondents reported a significant impact, including 10.0% of consultants, 7.1% of developers and 5.0% of contractors, indicating an increasing awareness of sustainability trends driven by the market.

On the other hand, only a minority perceived that consumer demand will have little to no effect, with 5.7% of consultants, 3.6% of developers and 1.4% of contractors reporting minimal influence. None of the consultants or

contractors perceived consumer demand to have no impact at all, while only 1.43% of developers held this view.

The perception among the majority of respondents that consumer demand has a moderate impact on green procurement likely reflects the transitional phase of market awareness in the Malaysian construction industry. At present, developers may be aware of the concept of sustainable construction but are not yet exerting strong pressure to influence procurement choices significantly. This finding aligns with the previous study of Sajjad et al. (2021) which highlights that developers are more likely to recognise the benefits of green procurement as environmental consciousness rises, thereby gradually intensifying market demand for green products. Furthermore, Li et al. (2023) highlight the rising social expectations, particularly from consumers who demonstrate a growing intention to purchase green-certified buildings, are placing greater pressure on developers to adopt more sustainable construction practices. As a result, developers may be increasingly motivated to minimise environmental pollution, adopt green branding initiatives and improve accountability through the publication of Environmental, Social and Governance (ESG) reports.

However, consumer-driven influence on green procurement remains moderate in various developing countries, including Malaysia, due to factors such as a lack of public awareness, low market demand for green buildings and cost sensitivities. According to Wang, Chen and Nah (2024), consequence awareness refers to an individual's understanding that their personal decisions impact both their immediate surroundings and the broader ecological system. A lack of such awareness diminishes individuals' sense of environmental responsibility and reduces their perceived value of investing in green buildings. In addition, purchasing power plays a pivotal role in shaping consumer behaviour. Ho et al. (2024) underscore that green buildings incur a price premium ranging from 3% to 20%, reflecting the higher costs associated with environmentally friendly materials and technologies. This premium frequently poses a substantial financial barrier, particularly for middle-income consumers who constitute a substantial segment of the housing market in developing countries. As a result, insufficient purchasing power restricts consumers' ability

and willingness to influence developers in embracing green procurement practices through their purchasing decisions.

Previous studies of Durdyev and Tokbolat (2022) and Rajendra and Mohanasundaram (2024) highlight that consumer demand may become a more potent motivator for the adoption of green procurement practices when supported by greater public awareness and advocacy. Developers should implement effective marketing strategies that not only inform but also engage potential buyers. These may include word-of-mouth promotion, exhibitions and promotional events that offer hands-on exposure to green technologies as well as targeted advertising campaigns that highlight the long-term value, efficiency and environmental benefits of green buildings. Moreover, government support such as tax incentives, grants and soft loan schemes can help offset the higher upfront costs typically associated with green buildings. These financial mechanisms can simultaneously enhance affordability for a larger group of customers and encourage developers to prioritise green procurement practices.

4.9.2 Mean Score and Standard Deviation

Based on Table 4.5, the top five drivers that influence the adoption of the green procurement practices are listed below:

(i) Environmental sustainability (Mean = 4.31; $\delta = 0.729$)

(ii) Implementation of incentive policies (Mean = 4.30; $\delta = 0.686$)

(iii) Regulations and standards of green procurement (Mean = 4.29; $\delta = 0.694$)

(iv) Availability of green suppliers (Mean = 4.24; $\delta = 0.633$)

(v) Innovation and technology (Mean = 4.24; $\delta = 0.774$)

Overall, environmental sustainability has been ranked as the primary driver which influences the adoption of green procurement practices. This finding aligns with the previous study of Nadeem, Mohamad and Nik Abdullah (2017) which highlights that awareness serves as a fundamental prerequisite for making well-informed decisions, shifting one's attitude and changing one's behaviour. Thus, the successful adoption of green procurement has been greatly aided by the growing awareness of environmental sustainability, as construction firms are increasingly motivated to align their procurement practices with

sustainability objectives. Similarly, a study of Opoku et al. (2022) emphasises that environmental drivers were perceived as the most influential factor in the adoption of green procurement. Stakeholders are increasingly concerned about the adverse environmental impacts of construction activities, such as pollution, deforestation, inefficient resource consumption and excessive waste generation.

Furthermore, the implementation of incentive policies has obtained the second ranking place among the 21 drivers identified. High initial costs have been identified as a significant barrier to the adoption of green procurement practices, particularly in developing countries. Green-based construction technologies are often essential for implementing sustainable procurement, however, their adoption typically involves substantial initial investment. These additional costs discourage firms from fully embracing green procurement even though it offers long-term environmental and economic benefits (Yap et al., 2024a). In order to address this challenge, Razali et al. (2021) underscore that robust governmental support through well-designed policies, initiatives and financial incentives is essential to accelerate the uptake of green technologies and guarantee quality control in sustainable practices. These incentives are essential for balancing upfront expenses, which lessens the financial strain on construction firms and encourages greater involvement in green procurement practices that aim to meet national sustainability goals.

Moreover, regulations and standards of green procurement received the third position. This finding is supported by the previous study of Wong, Chan and Wadu (2016) which underscores that the government's regulations and standards are the most significant drivers of green procurement. Governments are expected to take proactive leadership as "greening agents" to encourage and impact the national and international adoption of green procurement practices. Similarly, revisions to building rules and efficiency standards have also significantly accelerated the adoption of green materials (Shen, Zhang and Zhang, 2017). Furthermore, Shurrab, Hussain and Khan (2019) highlight that ISO certification is increasingly included as part of the environmental criteria during the pre-qualification phase of the tendering process. This suggests that green procurement practices are becoming a prevalent trend among organisations across the construction industry as they strive to comply with governmental environmental regulations.

The fourth driver that influences the adoption of green procurement practices is the availability of green suppliers. In conventional procurement practices, the selection of suppliers for construction projects often omits environmental considerations in favour of technological and financial efficiency. However, due to the greater dedication to environmental conservation and the long-term implications on business, construction firms now prioritise suppliers' environmental consciousness when selecting suppliers for a particular project (Konys, 2019). As a result, green suppliers are actively involved in producing greener products in an environmentally friendly manner to improve the environmental performance while maintaining profitability (Mardani et al., 2020). Furthermore, Shojaei and Bolvardizadeh (2020) underscore that green suppliers can actively implement comprehensive green supply chain management (GSCM) strategies that encompass the lifecycle of a product, from raw material sourcing to product recycling. These strategies enable suppliers to deliver environmentally friendly materials and products without compromising quality, cost or performance (Shojaei and Bolvardizadeh, 2020). Therefore, construction firms can rely on green suppliers to achieve their sustainability goals while maintaining high standards of quality, performance and cost-effectiveness.

Lastly, innovation and technology are ranked as the fifth drivers of the adoption of green procurement practices. According to Masyhur et al. (2024), the transition towards Industrial Revolution 5.0 (IR 5.0) is accelerating the adoption of environmentally friendly and sustainable solutions within the construction industry. National initiatives such as Construction Industry Transformation Programme (CITP), the Green Technology Master Plan (GTMP), and the 12th Malaysia Plan (RMK-12) further promote the use of innovative technologies including Industrialised Building Systems (IBS), 3D printing, Building Information Modelling (BIM), autonomous construction equipment and advanced construction materials. In addition, the integration of green technology and green assessment systems aids in resource conservation and carbon emission reduction through facilitating energy-efficient design, environmentally friendly material selection, and efficient waste reduction techniques. Shojaei and Bolvardizadeh (2020) further underscore that technological innovation significantly supports green initiatives in the

construction industry, particularly the remanufacturing supply chain of construction waste. Thus, direct government investment acts as a stimulant to improve the Green Technology Innovation Behaviour (GTIB) of construction firms, especially in the early phases of implementation.

Table 4.5: Mean Score and Standard Deviation of Drivers of Green Procurement Practices.

Ref	Drivers	Overall (N=140)			Developer (N=46)			Consultant (N=51)			Contractor (N=43)			Chi-square	Asymp. sig
		Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R		
	Policy and governance support														
D1	Availability of policies and guidelines	4.16	0.702	8	3.98	0.802	16	4.29	0.610	5	4.19	0.664	14	3.730	0.155
D2	Regulations and standards of green procurement	4.29	0.694	3	4.07	0.772	9	4.49	0.612	1	4.30	0.638	2	8.377	0.015*
D3	Implementation of incentive policies	4.30	0.686	2	4.22	0.696	2	4.39	0.603	3	4.28	0.766	6	1.351	0.509
D4	Campaigns and workshops	3.89	0.784	21	3.85	0.816	20	4.00	0.721	18	3.81	0.824	21	1.634	0.442
	Leadership and corporate strategy														
D5	Top management commitment	4.14	0.779	11	3.98	0.802	16	4.18	0.740	12	4.26	0.790	10	3.184	0.204
D6	Corporate social responsibility (CSR)	4.06	0.775	19	4.04	0.842	12	3.94	0.676	20	4.21	0.804	12	3.720	0.156
D7	Enhance reputation of client companies	4.11	0.784	15	4.02	0.802	13	4.08	0.688	16	4.23	0.868	11	2.656	0.265
	Economic and market dynamics														
D8	Achieving cost savings	4.15	0.873	10	4.20	0.806	4	4.16	0.857	13	4.09	0.971	20	0.104	0.950
D9	Market demand	4.09	0.763	17	4.09	0.839	8	4.04	0.692	17	4.14	0.774	17	0.636	0.728
D10	Gain competitive advantage in market	4.09	0.809	18	4.15	0.816	5	4.00	0.775	19	4.12	0.851	19	1.423	0.491
	Environmental and social responsibility														
D11	Environmental sustainability	4.31	0.729	1	4.28	0.750	1	4.41	0.606	2	4.21	0.833	13	1.061	0.588
D12	Provide healthier working environment	4.15	0.719	9	4.11	0.674	6	4.20	0.722	9	4.14	0.774	17	0.386	0.825
D13	Improving community health and quality of life	4.19	0.726	7	4.09	0.694	7	4.20	0.693	8	4.28	0.797	7	2.237	0.327
	Innovation and technological advancement														
D14	Innovation and technology	4.24	0.774	5	4.00	0.943	14	4.25	0.627	7	4.47	0.667	1	6.865	0.032*

D15	Provide proper assessment tool	4.11	0.730	14	3.91	0.755	19	4.18	0.654	11	4.26	0.759	9	5.378	0.068
	Stakeholder engagement and collaboration														
D16	Stakeholder values towards greening construction procurement	4.14	0.783	12	4.04	0.788	11	4.10	0.831	15	4.30	0.708	4	2.898	0.235
D17	Corporation and partnership	4.09	0.734	16	3.98	0.856	18	4.14	0.664	14	4.14	0.675	15	0.560	0.756
D18	Suppliers-induced benefits	4.02	0.809	20	3.85	0.894	21	3.94	0.785	21	4.30	0.674	3	7.457	0.024*
	Supply chain and resource availability														
D19	Availability of green products and services	4.23	0.639	6	4.04	0.631	10	4.35	0.658	4	4.28	0.591	5	6.159	0.046*
D20	Availability of green suppliers	4.24	0.633	4	4.20	0.687	3	4.27	0.603	6	4.26	0.621	8	0.204	0.903
D21	Establishment of reliable database	4.11	0.727	13	3.98	0.745	15	4.20	0.722	9	4.14	0.710	16	1.820	0.403

N = Sample size, SD = Standard Deviation.

Note:

**. The mean difference is statistically significant at the 0.01 level ($p < 0.01$).

*. The mean difference is statistically significant at the 0.05 level ($p < 0.05$).

4.9.3 Kruskal-Wallis H Test

Table 4.5 shows that there is no significant difference for all of the drivers except regulations and standards of green procurement, innovation and technology, suppliers-induced benefits and availability of green products and services.

The consultants and contractors had ranked “regulations and standards of green procurement” as one of the top three critical drivers influencing the adoption of green procurement practices, while the developers only ranked it at 9th. This scenario could be attributed to the distinct roles and priorities of these stakeholder groups. According to Bohari and Xia (2015), the government plays a vital role in promoting the adoption of green procurement through the establishment of environmental standards and regulatory frameworks. Consultants and contractors, who are directly involved in the execution and compliance of construction activities, are more likely to place a high value on regulations and standards, as non-compliance can lead to project delays, financial penalties or reputational damage. The absence of standardised procedures, established best practices and clear guidelines may create uncertainty during project planning and implementation, thereby increasing risks and project costs. On the contrary, developers, who bear the responsibility of financing a project, tend to prioritise economic outcomes over environmental or regulatory considerations. This finding aligns with a previous study of Onubi, Yusof and Hassan (2020) which underscores that private developers are largely motivated by profitability and may only support environmentally focused initiatives if they are aligned with significant economic returns. Private developers may view regulations and standards related to green procurement as secondary unless they directly increase revenue, in contrast to public developers who might be driven by social responsibility and political image. Thus, developers' economic-centric perspective may result in a lower priority ranking for regulations and standards compared to consultants and contractors.

Innovation and technology are ranked in first place by the contractors. Since contractors are primarily responsible for executing construction projects on-site, they are directly involved in implementing sustainable technologies and construction methods to ensure timely and efficient project delivery. As a result, they are more immediately affected by innovations in construction processes,

tools and equipment. According to a previous study by Isa and Abidin (2021), the availability of advanced technologies enables contractor firms to shift from conventional construction approaches toward more sustainable practices. These technologies facilitate the adoption of eco-innovative (EI) solutions that not only mitigate environmental impact but also lowering operational costs, offering both environmental and economic benefits. Furthermore, Qian et al. (2023) underscore that the innovation capability is a fundamental prerequisite not only for corporate competitiveness but also for achieving national and sectoral sustainable development objectives. Green Technology Innovation (GTI) accelerates the shift to a low-carbon economy by improving the efficiency of current technology. The possibility that contractors will successfully use GTI is greatly increased by strong innovation capabilities. Moreover, contractors have a great chance to spur innovation by integrating advanced technologies such as artificial intelligence and big data into construction processes.

Suppliers-induced benefits are identified as one of the top three critical drivers influencing the adoption of green procurement practices among contractors, whereas the developers and consultants only ranked it at 21st. This reflects the contractors' close engagement with suppliers during the project execution phase, where they rely heavily on the timely and sustainable delivery of materials. According to Ali et al. (2023), the construction industry is shifting toward a shared commitment to environmental sustainability, fostering collaborations that go beyond considerations of cost and availability. In addition, effective information sharing (IS) and strong environmental capabilities (EC) of suppliers significantly enhance green supply chain management (GSCM) performance, enabling contractors to achieve both environmental goals and competitive advantage (Woo et al., 2016). This reflects that information sharing, such as product specifications, environmental certifications, and logistics data, helps streamline the project execution, reduce waste and ensure compliance with environmental standards. In contrast, the lower ranking by developers and consultants may be explained by the findings of Shen, Zhang and Zhang (2017) and Koebel et al. (2015) which highlight that developers place limited importance on collaboration with green materials suppliers. Their access to suppliers has a negligible effect on the adoption of green materials, likely

because developers and consultants are more involved in the planning, design and financial aspects of projects, with less direct interaction with suppliers.

Availability of green products and services had been ranked among the top five drivers influencing the adoption of green procurement practices by consultants and contractors, while developers ranked it lower at 10th place. This finding could be explained by the fact that the accessibility of environmentally friendly materials and technologies is essential for lowering the ecological footprint, since the construction industry strives to meet sustainability targets (Nadeem, Mohamad and Nik Abdullah, 2017; Razali et al., 2021). As a result, consultants and contractors are more aware of the availability of green products because they are actively involved in procuring materials to meet these targets. According to Khaderi et al. (2022) and Yap et al. (2024a), high costs and limited incentives often deter developers from embracing green procurement in construction. However, expanding the availability of green products and services can enhance market competition, thereby making them more affordable and accessible. This increased availability allows consultants and contractors to more thoroughly assess and compare the features and pricing of green products, encouraging better decision-making and facilitating the broader implementation of green procurement practices.

4.10 Spearman's Correlation Test

Table 4.6 shows the results of Spearman's correlation test, which was conducted to evaluate the relationship between the adoption of green procurement practices and the drivers enhancing its adoption level in Malaysian construction projects. According to Yan et al. (2019), a relationship is deemed extremely strong if the coefficient is 0.80 or higher, strong if it is between 0.60 and 0.79, moderate if it is between 0.40 and 0.59, weak if it is between 0.20 and 0.39, very weak if it is between 0 to 0.19 and there is no correlation if it is equal to 0. In this study, the variables are deemed to exhibit a weak to moderate relationship. However, the strongest correlation was observed between the variables "Qualification of stakeholders based on knowledge and experience" (P1) and "Improving community health and quality of life" (D13), with a correlation coefficient of 0.549.

Ruparathna and Hewage (2015) and Shurrab, Hussain and Khan (2019) underscore that integrating green procurement practices in the construction projects reduces the use of toxic materials, improves air and water quality and minimises waste disposal, all of which healthier environments. Practices such as reusing and recycling construction waste help mitigate air pollution compared to conventional waste disposal methods such as incineration. Furthermore, incorporating green roofs into buildings reduces interior temperatures, enhances indoor air quality and shields occupants from ultraviolet (UV) light (Khan et al., 2018; Ofek, Akron and Portnov, 2018). In order to effectively implement these health and environmental benefits, stakeholders must be well-qualified and possess the necessary knowledge and experience. According to Khahro et al. (2021), stakeholders that have access to green expertise and specialised resources are better equipped to make informed decisions that align with environmental objectives. This demonstrates that stakeholders with a thorough understanding of environmental issues are better able to choose solutions that go beyond simple compliance and satisfy regulatory standards. Their decisions have the potential to maximise the long-term benefits of green procurement by producing tangible improvements in environmental quality, public health and overall quality of life.

As indicated by the result, environmental sustainability (D11) emerges as one of the main drivers influencing the adoption of green procurement

practices. This driver stands out as a significant concern with a total of 15 significant correlations across all practices. According to Lima et al. (2021), sustainability in construction is crucial to satisfying the demands of both the current and future generations by preserving natural resources, energy, and water through practices such as reuse, recycling, innovative design and waste minimisation. Adopting green procurement practices, such as the incorporation of green specifications into the contract (P7), can result in significant social, economic and environmental benefits. According to Bohari et al. (2017), the contractual requirements of a traditional building contract would include the selection of material, chemical composition and functional features of the products to guarantee that these green standards are fulfilled. Designers will take great effort to suggest sustainable materials that are derived from sustainable resources. Thus, building materials with the lowest resource inputs, waste and emissions into the environment would be prioritised. Furthermore, this driver also motivates the adoption of waste management and recycling (P10). Mohammed et al. (2020) highlight that effective waste management can mitigate environmental degradation by prioritising the reduction, reuse and recycling of materials and components. Reducing material wastage in the construction industry through improved early planning, effective design techniques and procurement optimisation can significantly reduce the ecological footprint. Furthermore, reusing construction materials such as steel and concrete components lowers the need for extracting raw materials, thereby conserving scarce natural resources. Additionally, recycling practices, including the use of recycled aggregates and other secondary materials, encourage the shift to a circular construction economy and divert waste from landfills.

In addition, “provide healthier working environment” (D12) emerged as another significant driver strongly associated with the adoption of green procurement practices, with a considerable correlation count of 15. This finding indicates that, beyond environmental concerns, the health and well-being of workers remain a central priority in promoting sustainable practices within construction projects. For instance, the adoption of energy-efficient machinery and equipment (P9) is heavily influenced by this driver. According to Xue et al. (2022), construction machinery, such as loaders, excavators and forklifts, which predominantly rely on diesel engines, are major sources of harmful emissions

such as volatile organic compounds (VOCs) and nitrogen oxides, contributing significantly to the deterioration of air quality. These pollutants not only exacerbate environmental degradation but also pose substantial health risks to workers through prolonged exposure. In order to address this issue, the integration of electrohydraulic hybrid systems in earthmoving equipment integrates hydraulic and electric systems to optimise energy use and minimise carbon dioxide emissions (Quan et al., 2021). Such innovations directly enhance occupational health and safety conditions by minimising workers' exposure to hazardous pollutants and alleviating the physical and environmental stresses typically associated with conventional construction activities. Similarly, this driver also affects the integration of Building Information Modeling (BIM) for sustainability (P14). BIM facilitates the systematic management of project data and design in digital form throughout the project lifecycle, which enhances stakeholder coordination, communication and decision-making. By utilising 3D models, BIM enables comprehensive evaluations of environmental performance and supports the implementation of sustainability measures (Ferdosi et al., 2023). By improving the planning and management of construction activities, this ultimately helps to provide safer and healthier workplace conditions for construction workers. A safe and healthy work environment enhances worker well-being and substantially reduces the incidence of health issues such as allergies, asthma attacks and headaches while also lowering the risk of construction-related accidents (Ruparathna and Hewage, 2015; Oni, Olanrewaju and Khor, 2024).

Furthermore, the result demonstrated that improving community health and quality of life (D13) appeared as another crucial driver closely associated with the adoption of green procurement practices, with a noteworthy correlation count of 15. In particular, this driver presents a moderate relationship with utilising renewable energy sources or technology (P13), with a correlation coefficient of 0.488. This finding aligns with a previous study of Tarkar (2022) which highlights that those hospitals implemented solar lighting, green cement, fly ash, green roofs and rainwater harvesting systems not only improving the building occupants' quality of life but also contributing to lower employee absenteeism. Similarly, Khan and Al-Ghamdi (2021) and Chen et al. (2024) highlight that the adoption of solar panels and wind turbines can reduce the

demand for fossil fuels, thereby lowering greenhouse gas emissions and fostering healthier communities. In urban contexts, integrating solar technology into infrastructure, such as photovoltaic (PV) parking lot canopies and PV noise barriers, provides further advantages for the environment and public health by mitigating noise pollution and reducing urban heat (Vijayan et al., 2023). Additionally, improving community health and quality of life is also positively associated with procuring green building technologies (P15). Green buildings frequently incorporate water-saving technologies, such as high-efficiency fixtures and rainwater harvesting systems, in response to the growing global demand for freshwater conservation (Lai et al., 2023). Thus, the results confirm that efforts to improve community health and quality of life are not only socially beneficial but also instrumental in driving the adoption of renewable energy and green building technologies, reflecting the growing importance of health-focused outcomes in green procurement.

Table 4.6: Correlation Between Practices and Drivers of Green Procurement.

Practices / Drivers	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	Total Sig.
D1	0.532**	-	0.449**	0.432**	0.264**	-	0.260**	0.267**	0.347**	0.428**	-	0.316**	0.430**	0.430**	0.317**	12
D2	0.404**	0.318**	0.389**	0.423**	-	-	0.380**	0.250**	0.356**	0.375**	-	0.242**	0.429**	0.324**	0.433**	12
D3	0.293**	-	0.363**	0.344**	-	-	-	-	0.253**	0.309**	-	0.276**	0.213*	0.356**	0.244**	9
D4	0.255**	-	-	0.194*	0.295**	-	0.177*	0.299**	0.340**	0.237**	-	0.267**	0.299**	0.359**	0.319**	11
D5	0.342**	-	0.285**	0.332**	0.265**	0.190*	0.345**	0.230**	0.263**	0.382**	-	0.329**	0.334**	0.397**	0.295**	13
D6	0.363**	-	0.268**	0.296**	0.362**	0.244**	0.363**	0.433**	0.438**	0.331**	0.330**	0.366**	0.373**	0.310**	0.286**	14
D7	0.440**	0.177*	0.340**	0.312**	0.246**	-	0.218**	0.412**	0.503**	0.465**	0.258**	0.311**	0.415**	0.421**	0.333**	14
D8	0.365**	0.188*	-	0.230**	0.224**	0.182*	0.186*	0.316**	0.435**	0.356**	0.300**	0.171*	0.253**	0.364**	0.309**	14
D9	0.205*	-	-	0.267**	0.245**	0.185*	0.263**	0.279**	0.303**	-	0.314**	0.267**	-	0.247**	-	10
D10	0.280**	-	0.285**	-	0.198*	-	-	0.360**	0.333**	0.273**	0.347**	0.315**	0.362**	0.288**	0.232**	11
D11	0.309**	0.171*	0.327**	0.380**	0.241**	0.280**	0.431**	0.215*	0.394**	0.408**	0.337**	0.312**	0.400**	0.349**	0.303**	15
D12	0.315**	0.212*	0.279**	0.267**	0.197*	0.287**	0.281**	0.346**	0.361**	0.358**	0.213*	0.209*	0.342**	0.372**	0.302**	15
D13	0.549**	0.361**	0.393**	0.287**	0.303**	0.228**	0.351**	0.290**	0.419**	0.332**	0.202*	0.266**	0.488**	0.514**	0.477**	15
D14	0.365**	0.227**	0.334**	0.365**	-	-	0.271**	0.248**	0.408**	0.467**	0.208*	0.171*	0.400**	0.420**	0.417**	13
D15	0.384**	0.261**	0.354**	0.317**	0.294**	-	0.190*	0.244**	0.387**	0.357**	0.190*	0.272**	0.485**	0.383**	0.386**	14
D16	0.289**	-	0.265**	0.323**	0.401**	0.203*	0.405**	0.182*	0.408**	0.353**	0.273**	0.322**	0.297**	0.363**	0.360**	14
D17	0.438**	-	0.272**	0.382**	0.199*	0.197*	0.283**	0.249**	0.346**	0.363**	0.255**	0.485**	0.325**	0.238**	0.375**	14
D18	0.309**	-	-	0.267**	0.235**	0.196*	-	0.209*	0.404**	0.306**	0.207*	0.316**	0.344**	0.296**	0.321**	12
D19	-	0.272**	0.287**	0.413**	-	0.180*	0.239**	-	0.250**	0.370**	-	0.311**	0.339**	0.248**	0.295**	11
D20	0.217*	-	0.259**	0.327**	0.175*	-	0.181*	-	0.194*	0.243**	0.258**	-	0.351**	0.173*	0.245**	11
D21	0.311**	-	0.209*	0.278**	0.256**	-	-	-	0.283**	0.242**	0.220**	0.181*	0.360**	0.317**	0.267**	11
Total Sig.	20	9	17	20	17	11	17	17	21	20	15	20	20	21	20	

**. Statistically significant correlation at the 0.01 level (2-tailed).

*. Statistically significant correlation at the 0.05 level (2-tailed).

4.11 Factor Analysis

4.11.1 Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test

The 21 drivers of green procurement practices in the construction industry were regrouped using an exploratory factor analysis (EFA) with varimax rotation. As shown in Table 4.7, the Kaiser-Meyer-Olkin (KMO) measure yielded a value of 0.903. Since the KMO value exceeds the minimum acceptable threshold of 0.50, it confirms that the sample adequacy is acceptable for conducting factor analysis. Furthermore, the KMO values lie within the range of 0.80 to 1.00 demonstrates excellent sampling adequacy. Moreover, Bartlett's test of sphericity produced a value of 1449.784 with a significance level of $p < 0.001$. As the Bartlett's test of sphericity yielded a significance value less than 0.05, the result indicates that the variables are sufficiently intercorrelated, thus supporting the appropriateness of proceeding with factor analysis (Shrestha, 2021).

Table 4.7: Results of KMO and Bartlett's Tests.

Parameter	Value
Kaiser–Meyer–Olkin measure of sampling adequacy	0.903
Bartlett's test of sphericity	
Approximate chi-square value	1449.784
Degree of freedom	210
Significance	<0.001

Furthermore, the number of underlying factors was determined using both the scree plot and Kaiser's criterion, which recommends retaining only those factors with eigenvalues greater than 1.00 (Williams, Onsman and Brown, 2010). As illustrated in Figure 4.10, four significant factors are extracted from the analysis of the 21 drivers. Table 4.8 shows that these four factors account for 60.549% of the total variance. This satisfies the minimum threshold of 60% required to demonstrate construct validity and ensure the stability of the factor structure (Hair et al., 2019). Each driver was subsequently assigned to one of the four factors based on its loading, using a minimum threshold of 0.400. Table 4.9 and Figure 4.11 present the classification of the 21 drivers of green procurement practices into the four identified principal factors.

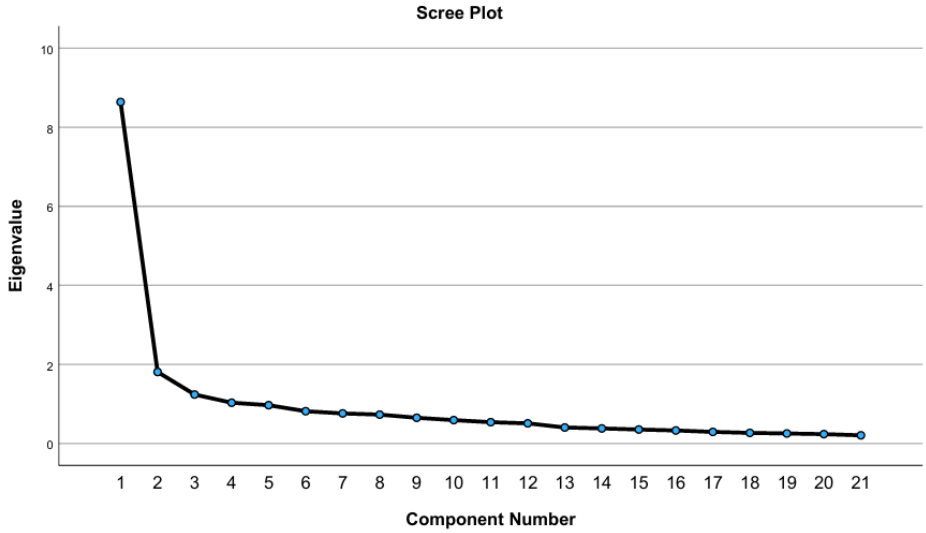

Figure 4.10: Scree Plot for 21 Drivers of Green Procurement Practices.

Table 4.8: Interpretation of Total Variance.

Component	Initial Eigenvalues		
	Total	Percentage Of Variance (%)	Cumulative Percentage (%)
F1	3.475	16.547	16.547
F2	3.200	15.238	31.785
F3	3.191	15.195	46.980
F4	2.850	13.569	60.549

Table 4.9: Factor Loading and Variance Explained.

Details of Underlying Factors	Factor Loading	Variance Explained (%)	Average Mean	Cronbach Alpha Value
Factor 1: Institutional and Strategic Support		16.547	4.204	0.858
Availability of policies and guidelines	0.774			
Regulations and standards of green procurement	0.729			
Improving community health and quality of life	0.637			
Implementation of incentive policies	0.603			
Top management commitment	0.601			
Provide proper assessment tool	0.507			
Innovation and technology	0.496			
Factor 2: Market and Business Competitiveness		15.238	4.110	0.812
Achieving cost savings	0.817			
Gain competitive advantage in market	0.774			
Market demand	0.703			
Enhance reputation of client companies	0.645			
Factor 3: Availability of Green Resources and Infrastructure		15.195	4.223	0.812
Availability of green suppliers	0.867			
Availability of green products and services	0.811			
Establishment of reliable database	0.675			
Environmental sustainability	0.448			
Factor 4: Stakeholder Engagement and Social Responsibility		13.569	4.058	0.818
Corporate Social Responsibility (CSR)	0.735			

Campaigns and workshops	0.674	
Provide healthier working environment	0.600	
Corporation and partnership	0.438	
Stakeholder values towards greening construction procurement	0.422	
Suppliers-induced benefits	0.421	
Cumulative variance explained		60.549

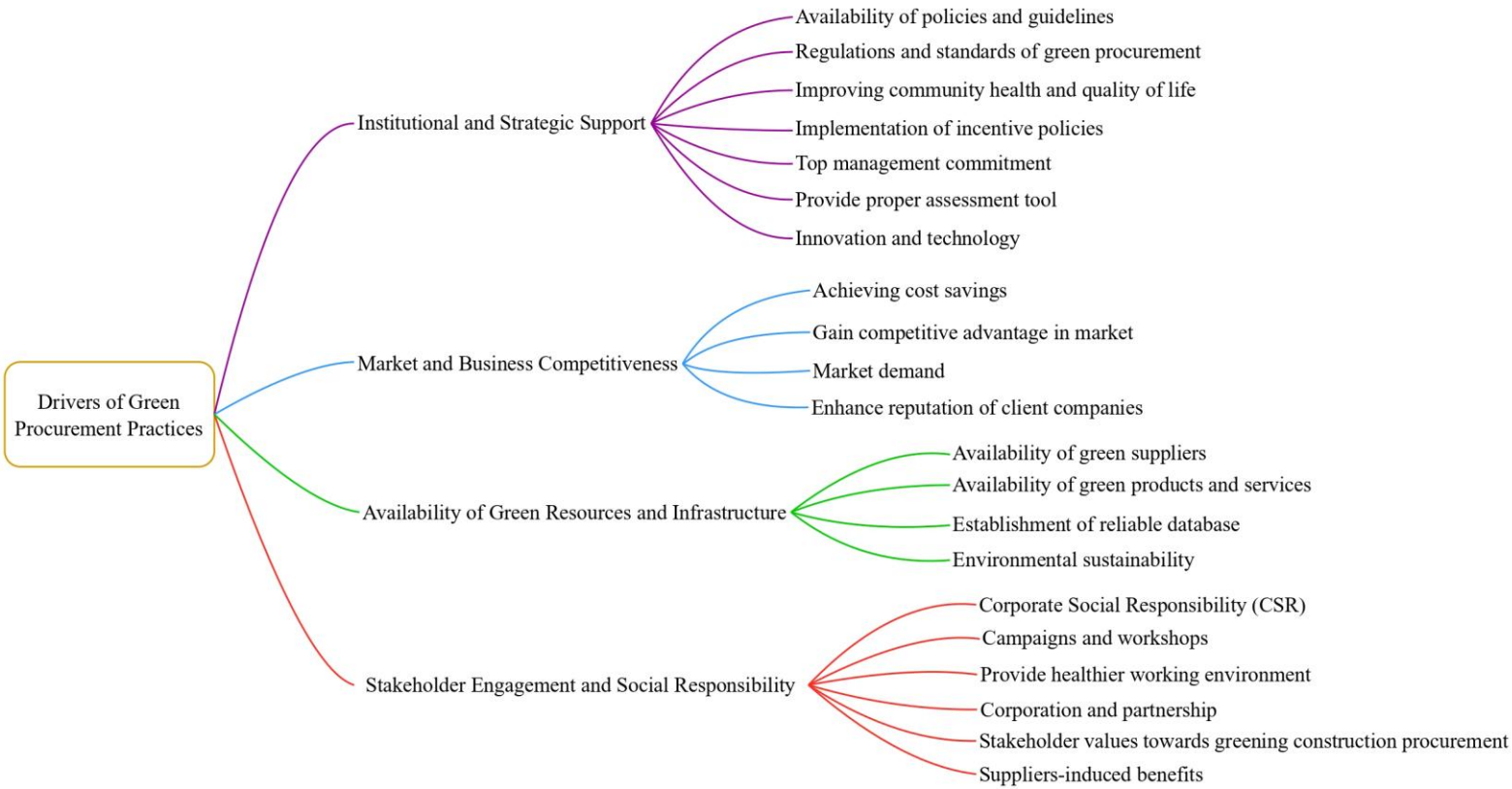

Figure 4.11: Factor Profile for 21 Drivers of Green Procurement Practices in Construction Industry.

4.11.2 Extraction of Underlying Factor

Factor 1: Institutional and Strategic Support

The effective implementation of green procurement practices in the construction industry largely hinges on the presence of robust institutional and strategic support. According to Bidin et al. (2020), government policies and guidelines foster a mindset dedicated to adhering to specific environmental rules and regulations at the project level. In the absence of a clear policy framework or regulatory requirement, construction stakeholders may lack both the direction and motivation to implement green procurement practices. To address this, environmental criteria such as compliance with International Standards Organisation (ISO) certifications could be incorporated into the pre-qualification phase of the tendering process. Shortages of green materials can be more successfully resolved once these mandatory standards are uniformly implemented for all green products, services and practices. This will allow the construction industry to adopt green procurement more widely (Razali et al., 2021). This demonstrates that the availability of policies and guidelines, along with established regulations and standards, offers a fundamental framework that legitimises green procurement and aligns construction practices with national sustainability objectives.

Moreover, the implementation of incentive policies further motivates organisations to pursue greener alternatives, even if such options initially entail greater costs or uncertainties. For instance, even though green products are usually more expensive than conventional products, incentives such as tax deductions or additional gross floor area might motivate construction firms to purchase them (Wong, Chan and Wadu, 2016). However, the presence of regulatory and financial support alone may not be sufficient. The commitment of top management is equally vital, as they are the primary decision-makers within an organisation. Leadership that embraces sustainability as a core organisational value creates a culture where all project team members work together to achieve the best possible environmental performance in construction projects (Bohari et al., 2017).

In order to ensure the decisions made about green procurement are data-driven, consistent, and environmentally sound, proper assessment tools are utilised to systematically evaluate both environmental performance and

procurement outcomes. Life Cycle Assessment (LCA) is one of the assessment tools that enables the comprehensive evaluation of environmental impacts associated with construction projects throughout the project life cycle, from raw materials extraction to disposal at the end of usable life. As an illustration, the LCA helps determine environmentally friendly materials and methods that are appropriate for road construction. Furthermore, the integration of advanced technologies such as Artificial Intelligence (AI) into LCA enhances the precision and efficiency of environmental evaluations. In addition to facilitating better decision-making through the analysis of complex data sets, AI optimises supply chains by lowering logistical energy consumption as well as improving waste classification for recycling (Regona et al., 2024). By embracing technological innovations, construction firms can better satisfy strategic green procurement goals and promote environmental sustainability in project delivery.

Ultimately, these institutional and strategic enablers contribute to broader social objectives, particularly improving community health and overall quality of life. By integrating environmental considerations into procurement strategies, the construction industry can significantly reduce pollution, enhance living environments and support sustainable urban development (Shurrab, Hussain and Khan, 2019). All of these factors work together to establish a cohesive framework of institutional and strategic support, thereby positioning green procurement as an integral element of responsible and forward-thinking construction practices rather than a peripheral initiative.

Factor 2: Market and Business Competitiveness

The adoption of green procurement practices in the construction industry is increasingly driven by market-oriented motivations and the pursuit of business competitiveness. Shurrab, Hussain and Khan (2019) underscore that energy-efficient designs and recyclable products can significantly reduce energy and resource consumption as well as utility and disposal expenses. For instance, contractors may benefit from lower hazardous waste management fees and reduced administrative costs associated with compliance reporting. Moreover, although the initial costs of green materials may be higher, they usually require less energy, water and fuel during operation, which lowers operational and

maintenance costs over the life cycle of a project and offsets the greater upfront investment (Yap et al., 2024b).

Similarly, green buildings are no longer viewed solely as environmentally responsible structures but are also seen as symbols of modern consumer identity and future-oriented living as environmental concerns become increasingly embedded in societal values. Thus, consumers are more inclined to invest in properties that reflect social responsibility and sustainability trends. This shift in perception has significantly increased market demand (Ho et al., 2024). In response to this growing demand, developers are increasingly motivated to integrate environmentally friendly materials and products into their projects in order to deliver green buildings. A developer's reputation and public image can be greatly improved by demonstrating a strong commitment to delivering green buildings. This helps the developer stand out from competitors and improves its competitive position in the market (Oguntona et al., 2019).

Factor 3: Availability of Green Resources and Infrastructure

Environmental sustainability is a fundamental consideration in modern construction practices. According to Opoku, Agyekum and Ayarkwa (2022), incorporating sustainability principles into the planning and construction phases is essential to achieve both national and global environmental goals, including SDG 11 and SDG 15, which place a strong emphasis on sustainable cities and communities as well as the preservation of terrestrial ecosystems. However, there are still several barriers to the successful application of green construction practices despite these global commitments. A common aversion to risk, along with the high expense of procurement practices, are the common factors that hinder the establishment of sustainable supply chains. Moreover, the availability of accurate, reliable and up-to-date information on environmentally friendly products, materials and technologies is crucial to the successful application of green construction practices.

In conventional practices, ecological efficiency is frequently overlooked when selecting suppliers for construction projects in favour of technological and financial efficiency. However, this priority has changed as a result of increasing awareness of environmental conservation and its long-term business implications. Construction firms are increasingly taking environmental

responsibility of suppliers into account during the selection process (Quan, Zeng and Liu, 2018; Konys, 2019). In this context, the availability of green suppliers is vital since it guarantees a consistent and reliable source of environmentally certified materials, products and technologies. Without a robust supplier network aligned with sustainability standards, construction firms may encounter significant obstacles in sourcing the materials required for green construction.

Nevertheless, the availability of green products and services remains a critical challenge. A previous study conducted by Runtuk, Ng and Ooi (2024) highlights that the limited supply of environmentally friendly materials is a prominent barrier, often leading to supply chain disruptions and difficulties in meeting project timelines. This scarcity not only hinders the scalability of sustainable construction practices but also compromises the consistency of green supply chains. To mitigate these challenges, manufacturing firms are encouraged to diversify their supplier base in order to lessen their reliance on any one source. In addition, the establishment of a reliable database containing verified information on green products, suppliers and technical specifications is crucial. Nketiah et al. (2024) emphasise that such a well-maintained database can significantly support research and development (R&D) efforts by offering detailed insights into current sustainable practices and revealing areas for further innovation and improvement.

Factor 4: Stakeholder Engagement and Social Responsibility

According to Bidin et al. (2020), stakeholder perceptions significantly influence the outcomes of construction projects, while stakeholder commitment, capability and motivation are necessary components for project success. A study conducted by Fu et al. (2020) highlights that although stakeholders may have diverse objectives, promoting sustainable development in the construction industry requires their collective green behaviour, which is based on values and social responsibility. As project financiers and initiators, developers play a crucial role among these stakeholders. Their dedication to green procurement practices influences the decisions made by architects, engineers and suppliers.

As part of stakeholder engagement, Corporate Social Responsibility (CSR) strengthens a construction firm’s commitment to sustainability by addressing environmental, social, and ethical responsibilities. By aligning

corporate operations with sustainability goals, developers can enhance efficiency, reduce emissions and waste and minimise long-term environmental impacts (Ajibike et al., 2023). Khojastehpour and Shams (2020) further underscore that CSR strengthens stakeholder relationships and trust, which eventually contributes to a competitive advantage. Due to varying environmental regulations and societal expectations across different countries, managing ecological stakeholders poses additional challenges for multinational corporations (MNCs). However, CSR remains a vital instrument for promoting ethical conduct, transparent communication and long-term sustainability in diverse markets.

Furthermore, providing a healthier working environment is another key element of CSR in construction. The construction industry is especially vulnerable to health and safety issues due to the hazardous nature of construction activities (Fotiadis et al., 2023). Additionally, heavy workloads, strict deadlines, job insecurity and restricted access to healthcare lead to mental health issues such as depression, anxiety and stress conditions in construction workers. These circumstances may result in reduced productivity, increased absenteeism and a greater risk of accidents. Hence, ensuring a safe and supportive work environment is essential for protecting construction worker welfare, maintaining industry performance as well as fulfilling CSR commitment (Kumar Singh et al., 2024).

Despite the increased emphasis on sustainability, some developers lack the technical expertise and awareness required to effectively implement green procurement. In order to bridge these knowledge gaps, structured programs such as workshops, seminars and conferences are necessary to promote active stakeholder participation, share expertise, and encourage teamwork in the advancement of green procurement practices (Okoye, Odesola and Okolie, 2021).

Moreover, the private construction firms are able to address the high upfront costs, risks and uncertainties associated with green innovation through corporations and partnerships such as Joint Ventures (JV) and Public-Private Partnerships (PPPs). These collaborative models also facilitate greater access to financial resources for the development and implementation of green building technologies, sustainable construction materials and green procurement

practices, while simultaneously contributing to the achievement of the SDG (Sajjad et al., 2021; Akomea-Frimpong, Jin and Osei-Kyei, 2022). In addition, supplier-induced collaborations, such as partnerships between developers and green materials suppliers, can improve the efficiency and green procurement practices by increasing transparency across the supply chain and fostering the sharing of vital circularity-related information (Rizos and Bryhn, 2022).

4.11.3 Comparison among Different Countries

This section provides an in-depth overview of the key drivers of green procurement in both developed countries, such as the Netherlands, Spain, Sweden and Germany as well as developing countries such as Hong Kong, Brazil, Pakistan, China, Malaysia and Romania. Even though the scope and objectives of each study may differ, they collectively contribute to a broader understanding of the factors influencing green procurement within varying national contexts. All referenced studies were published after 2016.

As shown in Table 4.10, institutional and strategic support (F1) as well as stakeholder engagement and social responsibility (F4) emerge as the most prominent drivers, each was identified in eight out of nine studies. This demonstrates that there is a strong global consensus on the importance of governmental policies, regulatory frameworks, leadership commitment and collaborative stakeholder efforts in promoting green procurement in the construction sector, regardless of the development status of a country.

On the other hand, market and business competitiveness (F2) is moderately emphasised and present in four out of nine studies. This factor tends to be more prominent in developing countries, where green procurement is increasingly viewed as a means of gaining a competitive advantage and improving market positioning. However, developed countries may have already considered that green competitiveness is frequently incorporated into corporate operations and is no longer perceived as a distinct driver.

However, the availability of green resources and infrastructure (F3) is restricted to a single study. This may reflect disparities in infrastructure readiness and green supply chain maturity across countries. Established green marketplaces and supply chains in developed countries may lessen the perceived urgency of this factor. Conversely, the market supply of green products may be

limited in developing countries, which restricts the project teams from procuring sustainable materials. The effective implementation of green procurement practices in the construction industry is severely hampered by the lack of reliable green supply chains and dedicated green suppliers (Yap et al., 2024a). As a result, this underlying factor should be given more consideration as a key enabler of green procurement, even though it only has limited representation in existing studies. Addressing this gap could significantly increase the viability of sustainable practices, particularly in contexts where green infrastructure is still underdeveloped.

Table 4.10: Comparison with Previous Studies.

Countries	Factors / Current Study / Authors	F1 Institutional and Strategic Support	F2 Market and Business Competitiveness	F3 Availability of Green Resources and Infrastructure	F4 Stakeholder Engagement and Social Responsibility
European Union (EU) (e.g., Netherlands, Spain, Germany)	(Hinterhuber and Khan, 2025)				x
Sweden	(Santos, Lozano and Barreiro-Gen, 2024; Hinterhuber and Khan, 2025)	x			x
Hong Kong	(Wong, Chan and Wadu, 2016)	x		x	x
Brazil	(Santos, Lozano and Barreiro-Gen, 2024)	x	x		
Pakistan	(Khahro et al., 2021)	x	x		x
China	(Li, Ding and Sun, 2019)	x			x
China	(Opoku et al., 2022)	x	x		x
Malaysia	(Bidin et al., 2020)	x			x
Romania	(Simion, Nicolescu and Vrîncut, 2019)	x	x		x
Frequency		8	4	1	8

4.12 Summary

The findings of this study are derived from data gathered from 140 construction industry professionals working in the Malaysian construction industry, particularly in the Klang Valley region. The survey achieved an overall response rate of 56%. A reliability analysis confirmed that the collected data established good and excellent internal consistency. Additionally, SPSS analysis yielded a p-value of less than 0.001 for both green procurement practices and drivers, indicating a significant deviation from normality. Moreover, descriptive statistics, including mean scores and standard deviations, identified the five most prominent green procurement practices as: E-procurement, Procuring non-toxic and low Volatile Organic Compounds (VOCs) materials, Waste management and recycling, Purchasing green products and services and Giving preference to certified products. Similarly, the key drivers influencing the adoption of green procurement practices were found to be: Environmental sustainability, Implementation of incentive policies, Regulations and standards of green procurement, Availability of green suppliers and Innovation and technology.

Furthermore, the Kruskal-Wallis H test results revealed statistically significant differences in the perceptions of green procurement practices and drivers among developers, consultants and contractors. Among the 15 practices, notable differences were observed in the areas of "purchasing green products and services" and "e-procurement". There are statistically significant variations among the 21 drivers that influence green procurement practices in the construction industry, including “regulations and standards of green procurement”, “innovation and technology”, “suppliers-induced benefits” and “availability of green products and services”. In addition, Spearman’s correlation test indicated a positive relationship between practices and drivers of green procurement, with the highest correlation coefficient observed at 0.549. Last but not least, the factor analysis effectively uncovered four key underlying factors from the 21 drivers of green procurement practices within the construction industry.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a comprehensive summary of the earlier chapters, with a particular focus on the research methodology employed to accomplish the study's objectives and uncover key findings. It also outlines the practical implications of the study for the construction industry, along with an acknowledgement of its inherent limitations. A number of suggestions are made at the end of the chapter to guide future study in this field.

5.2 Conclusion

Construction industry serves as a major driver of economic growth and development all over the world, contributing significantly to a nation's gross domestic product (GDP). However, the Malaysian construction industry faces escalating sustainability challenges due to its continued reliance on conventional procurement practices, which contribute to high carbon emissions, resource depletion and environmental degradation. In response, green procurement practices have been introduced to mitigate these impacts by promoting resource efficiency, reducing waste and encouraging the use of environmentally responsible materials and technologies. Strengthening the adoption of green procurement practices is essential to advancing sustainability within the industry. Therefore, this study is conducted to explore the implementation of green procurement practices in the Malaysian construction industry. Through a comprehensive analysis of current practices and the key drivers influencing their adoption, this study aims to provide actionable insights that support the development of targeted strategies in order to enhance green procurement adoption and improve the industry's overall sustainability performance. These insights are crucial for guiding policy development, strengthening procurement frameworks, and encouraging a shift away from environmentally detrimental conventional methods. Thus, the objectives of this study are to identify green procurement practices in the Malaysian construction

industry, examine the drivers influencing their adoption and uncover the underlying factors affecting their successful implementation.

As part of this study, an extensive literature review was conducted, resulting in the identification of 15 green procurement practices and 21 key drivers influencing the adoption of green procurement within the construction industry. Following this, a structured survey was carried out in the Klang Valley region to gather data from construction stakeholders. To facilitate efficient data collection, a well-structured, closed-ended questionnaire was employed as the primary research instrument. The survey targeted construction practitioners from three major categories, which are developers, consultants, and contractors. A total of 140 sets of valid responses were successfully collected. Prior to conducting advanced statistical analyses, reliability and normality tests were performed to assess the internal consistency and distributional properties of the data. These preliminary tests confirmed the suitability of the dataset for further analysis.

In conclusion, all objectives outlined at the beginning of the study have been accomplished and are summarised below:

Objective 1:

The first objective of this study focuses on identifying green procurement practices in the Malaysian construction industry. A variety of alternatives were offered to the respondents in order to gauge their degree of agreement with the implementation of green procurement practices in the construction sector. The findings showed that the following five practices were the most significant: (1) E-procurement; (2) procuring non-toxic and low Volatile Organic Compounds (VOCs) materials; (3) waste management and recycling; (4) purchasing green products and services; (5) giving preference to certified products. Additionally, this study further revealed that the respondents had distinct viewpoints on five practices implemented in Malaysian construction projects, including purchasing green products and services and e-procurement, which developers rated slightly higher than the others.

Objective 2:

The second objective is to examine the drivers for green procurement practices in the construction industry. The respondents are required to indicate their level of agreement regarding the 21 drivers influencing the adoption of green procurement in the Malaysian construction industry. As a result, the five most critical drivers influencing green procurement applications are revealed as: (1) environmental sustainability; (2) implementation of incentive policies; (3) regulations and standards of green procurement; (4) availability of green suppliers; and (5) innovation and technology. Furthermore, it was discovered that respondents' perceptions varied significantly among the following drivers: regulations and standards of green procurement, innovation and technology, suppliers-induced benefits as well as availability of green products and services.

In addition, Spearman Correlation Test was employed to determine the degree of association between green procurement practices and drivers that influence the adoption of green procurement. It is shown that the variables "Qualification of stakeholders based on knowledge and experience" (P1) and "Improving community health and quality of life" (D13) had the strongest correlation, with a coefficient of 0.549. Moreover, the drivers that have shown the highest correlation counts of 15 are "environmental sustainability" (D11), "provide healthier working environment" (D12), and "improving community health and quality of life" (D13)

Objective 3:

Lastly, the third objective of this study is to uncover the underlying factors for green procurement practices in the construction industry. Therefore, this study employed factor analysis to conduct an in-depth examination of the 21 drivers influencing the adoption of green procurement practices. The analysis successfully identified four key underlying factors: institutional and strategic support, market and business competitiveness, availability of green resources and infrastructure as well as stakeholder engagement and social responsibility.

In addition, a comparative review was carried out to evaluate these four principal factors against those identified in studies conducted in other countries in order to further improve the worldwide understanding of their relevance.

Among these, institutional and strategic support as well as stakeholder engagement and social responsibility consistently emerged as dominant factors influencing green procurement adoption internationally. In contrast, the availability of green resources and infrastructure appeared to be less frequently emphasised across different national contexts, highlighting the need for greater attention and investment in these areas to strengthen the foundation for effective green procurement implementation.

5.3 Research Implications

This study can make a worthwhile contribution to the Malaysian construction industry and beyond. It provides valuable insights into the adoption and drivers of green procurement practices in the Malaysian construction industry. The identification of green procurement practices reflects the industry's growing awareness of environmental issues and the shift towards more sustainable construction methods. Similarly, the recognition of drivers and underlying factors highlights the importance of strong environmental commitment, a supportive policy framework and market readiness in driving the adoption of green procurement practices. Prioritising environmental sustainability, coupled with the implementation of incentive policies and robust governmental regulations, serves as a pivotal factor in encouraging industry stakeholders to embrace more sustainable procurement strategies. Together with access to green suppliers and technological advancements, these drivers form a strong foundation for advancing sustainability within the construction industry.

To further enhance the overall results, this study also examined the viewpoints of several key stakeholders in the construction industry, including developers, consultants and contractors. Furthermore, comparing the factor analysis results with those from other nations offers valuable insights into the underlying factors influencing the adoption of green procurement practices. This study enables a deeper understanding of regional variations and enhances the relevance and applicability of the results to a wider audience by placing the current findings into a broader geographical context. According to the comparative study, institutional and strategic support as well as stakeholder engagement and social responsibility are common factors influencing the

implementation of green procurement practices worldwide. Although the availability of green resources and infrastructure has not been extensively addressed in existing studies, it is a critical factor that requires more in-depth exploration to effectively support the successful adoption of green procurement practices.

In addition, this study offers valuable insights for policymakers, industry professionals and stakeholders by delivering evidence-based recommendations to embed green procurement into conventional construction practices. By encouraging environmental responsibility, promoting supportive policies and regulations, strengthening long-term resilience and fostering innovation and technology, this study advances the broader sustainability agenda within the construction sector. The significance of this study lies in its effort to quantify the key determinants of green procurement adoption in Malaysia, thereby bridging the gap between theoretical knowledge and practical implementation in sustainable construction.

5.4 Research Limitations

The findings of this study are subjected to a few inherent limitations. First and foremost, the study primarily focuses on identifying the current green procurement practices, the key drivers influencing their adoption and the underlying factors supporting green procurement implementation in the Malaysian construction industry. However, it does not examine the barriers or challenges that may hinder the adoption of such practices. As a result, the findings may not fully capture the complexities and constraints experienced by industry stakeholders. Future research is recommended to address these aspects, enabling a more comprehensive understanding of both the enablers and obstacles to green procurement. This would support the formulation of more robust and actionable strategies to advance green procurement practices within the construction industry.

Moreover, this study adopted a quantitative approach that mainly concentrated on numerical data and statistical analysis, which may have constrained the depth of contextual understanding. Although this method is effective for identifying patterns and general trends, the deeper contextual or

experiential aspects of participant responses can only be partially explored. Moreover, the reliance on the Likert scale to capture stakeholder perceptions presents limitations, as individual interpretations may vary, potentially affecting response consistency and accuracy. While the Likert scale remains one of the most effective tools for psychometric measurement and assessing respondent perceptions, its sole reliance may limit analytical depth. This limits the opportunity to capture more nuanced viewpoints or elaborate on individual experiences. Additionally, responses could not be expanded upon or clarified in real time due to the absence of qualitative methods such as interviews or focus groups. As a result, some valuable perspectives may have been missed.

In addition, this study focused on stakeholders in Klang Valley, which may restrict the generalisability of the findings. Although Klang Valley is a major economic and construction hub, its regulations, market conditions and green procurement practices may differ from those in other regions across the nation. As a result, the findings may not fully capture the perspectives or experiences of stakeholders working in various geographical, socio-economic or regulatory conditions.

Furthermore, the study's findings solely focus on developers, consultants, and contractors. It might have a narrow perspective on the topic as their opinions may be influenced by their professional interests and objectives. Moreover, this approach excludes the viewpoints of other key stakeholders, such as suppliers, policymakers and end-users, whose insights could contribute to a more comprehensive understanding of the implementation of green procurement practices. Thus, excluding certain groups could lead to the absence of important variables and different perspectives that could improve the overall findings.

5.5 Recommendations for Future Work

Future studies should seek to address the limitations associated with the use of the Likert scale in capturing stakeholder perceptions, experiences and interpretations. In order to overcome this limitation, incorporating alternative measurement techniques or mixed methods, such as interviews and focus groups, would allow for deeper probing to capture the rich experiences of industry

professionals, providing more nuanced insights into the rationale behind responses. Future studies can attain a more thorough and balanced understanding of green procurement practices and the underlying factors influencing their adoption in the construction industry by combining quantitative and qualitative data.

Furthermore, expanding future studies to other states in Peninsular Malaysia, as well as Sabah and Sarawak, is crucial, as these regions may exhibit differing levels of economic development, technological awareness and industry maturity, which could influence the adoption of green procurement practices. Additionally, broadening the respondents to include other key stakeholders, such as suppliers, policymakers and end-users, instead of only developers, consultants and contractors, will yield more thorough insights and improve the validity of the results. Moreover, expanding the sample size would further strengthen the statistical power of the study, reduce sampling bias and improve the generalisability of the results across various geographical and socio-economic circumstances.

Last but not least, industry stakeholders can leverage these findings to develop targeted strategies that enhance the adoption and integration of green procurement practices in construction projects, ultimately contributing to a more sustainable industry. As environmental degradation continues to escalate, it becomes increasingly vital for the construction industry to embrace more sustainable practices. In this regard, green procurement offers a practical and impactful means to reduce the environmental impact of construction activities, thereby assisting in the shift to a more sustainable built environment.

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APPENDICES

Appendix A: Questionnaire

EXPLORING GREEN PROCUREMENT TO DRIVE SUSTAINABLE PERFORMANCE FOR MALAYSIAN CONSTRUCTION INDUSTRY

Dear Sir / Madam,

My name is Tan Zi Yin, a final year undergraduate student from Universiti Tunku Abdul Rahman (UTAR) who pursuing Bachelor of Science (Hons) Quantity Surveying. I am currently carrying out a research for my Final Year Project, which is titled "Exploring Green Procurement To Drive Sustainable Performance For Malaysian Construction Industry". This research aims to the adoption of green procurement practices, identify the drivers that influence their adoption and uncover the underlying factors contributing to these practices within the Malaysian construction industry.

Green procurement refers to process of acquiring products and adopting environmentally friendly practices in compliance with rules, regulations, and guidelines, with the aim of minimising adverse environmental impacts. It takes into account the entire project lifecycle, from the extraction of raw materials, transportation, production, packaging, storage, usage, to disposal or recycling.

This questionnaire consists of four (4) sections, which may require not more than 10 minutes to complete. I would be greatly appreciate it if you could take a moment to complete this survey as it provides vital information that is relevant to the research. Please be noted that all responses will be treated confidentially and the data and information collected will only be used for academic purposes in data collection. If you do not wish to participate, you may quit the survey at any time.

If you have any queries regarding the research questions, please do not hesitate to contact me via phone (016-4222862) or email (ziyin0567@1utar.my).

Thank you for your valuable time and effort in participating in this survey. Your contribution is greatly appreciated.

Yours faithfully,
Tan Zi Yin

* Indicates required question

Section A: Demographic Information

This section seeks essential background information about the respondent.

1. What are the nature of your current organisation in the construction industry? *

Mark only one oval.

- ◯ Developer / Client
- ◯ Consultant
- ◯ Contractor

2. How many years of experience do you have in the construction industry? *

Mark only one oval.

- ◯ Less than 5 years
- ◯ 5 – 10 years
- ◯ 11–15 years
- ◯ 16 –20 years
- ◯ > 20 years

3. What is your position in the company? *

Mark only one oval.

- ◯ Executive
- ◯ Manager
- ◯ Senior Manager
- ◯ Top Management / Director

4. What is the type of project that you are mostly involved? *

Mark only one oval.

- ◯ Public
- ◯ Private

5. To what extent do you agree that adopting green procurement practices is essential for creating a more sustainable construction industry? *

Mark only one oval.

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

6. To what extent do you believe there is a pressing need for the construction industry in Malaysia to shift towards green procurement practices? *

Mark only one oval.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

7. To what extent do you agree that developing a comprehensive understanding of green procurement practices is essential to support sustainable development in the Malaysian construction industry? *

Mark only one oval.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Section B: Adoption of Green Procurement Practices in the Malaysian Construction Industry

This section seeks the respondent's perception of the adoption of green procurement practices within the Malaysian construction industry.

8. The table below shows a list of green procurement practices commonly adopted in the construction industry. In your opinion, please indicate the extent to which you agree that each of these practices is effectively adopted within the construction industry.

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Qualification of stakeholders based on knowledge and experience	◯	◯	◯	◯	◯
Opting for products with minimal or eco-friendly packaging	◯	◯	◯	◯	◯
Procuring non-toxic and low Volatile Organic Compounds (VOCs) materials	◯	◯	◯	◯	◯
Giving preference to certified products (e.g., eco-labelled products)	◯	◯	◯	◯	◯
Adoption of local suppliers	◯	◯	◯	◯	◯
Purchasing green products and services	◯	◯	◯	◯	◯
Incorporation of green specifications into the contract	◯	◯	◯	◯	◯
Purchase value of money (e.g., emphasizing the importance of value over cost)	◯	◯	◯	◯	◯
Adoption of energy-efficient machinery and equipment	◯	◯	◯	◯	◯
Waste management and recycling	◯	◯	◯	◯	◯
E-procurement (e.g., e-catalogues, e-ordering, e-tendering)	◯	◯	◯	◯	◯
Prefabrication and modular construction	◯	◯	◯	◯	◯
Utilising renewable energy sources or technology	◯	◯	◯	◯	◯
Integration of Building Information Modeling (BIM) for sustainability	◯	◯	◯	◯	◯
Procuring green building technologies	◯	◯	◯	◯	◯

Section C: Drivers for Green Procurement Practices in the Construction Industry

This section seeks the respondent's perceptions of the drivers for adopting green procurement practices within the Malaysian construction industry.

9. The table below presents various potential drivers for green procurement practices in the construction industry. In your opinion, please indicate the extent to which you agree with each driver as a motivating factor for green procurement in the construction industry.

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Availability of policies and guidelines (e.g., Government Green Procurement (GGP) guidelines)	⬭	⬭	⬭	⬭	⬭
Regulations and standards of green procurement (e.g., ISO certifications)	⬭	⬭	⬭	⬭	⬭
Implementation of incentive policies	⬭	⬭	⬭	⬭	⬭
Campaigns and workshops	⬭	⬭	⬭	⬭	⬭
Top management commitment	⬭	⬭	⬭	⬭	⬭
Corporate Social Responsibility (CSR)	⬭	⬭	⬭	⬭	⬭
Enhance reputation of client companies	⬭	⬭	⬭	⬭	⬭
Achieving cost savings (e.g., long-term financial benefits)	⬭	⬭	⬭	⬭	⬭
Market demand	⬭	⬭	⬭	⬭	⬭
Gain competitive advantage in market	⬭	⬭	⬭	⬭	⬭
Environmental sustainability	⬭	⬭	⬭	⬭	⬭
Provide healthier working environment	⬭	⬭	⬭	⬭	⬭
Improving community health and quality of life	⬭	⬭	⬭	⬭	⬭
Innovation and technology	⬭	⬭	⬭	⬭	⬭
Provide proper assessment tool (e.g., GBI, LEED, BREEAM)	⬭	⬭	⬭	⬭	⬭
Stakeholder values towards greening construction procurement	⬭	⬭	⬭	⬭	⬭
Corporation and partnership (e.g., Joint Ventures (JV), Public-Private Partnerships (PPPs))	⬭	⬭	⬭	⬭	⬭
Suppliers-induced benefits	⬭	⬭	⬭	⬭	⬭
Availability of green products and services	⬭	⬭	⬭	⬭	⬭
Availability of green suppliers	⬭	⬭	⬭	⬭	⬭
Establishment of reliable database	⬭	⬭	⬭	⬭	⬭

Section D: Future Outlook and Opportunities for Green Procurement Practices in the Malaysian Construction Industry

This section seeks the respondent's perceptions of the future outlook of green procurement practices in the Malaysian construction industry, including insights into future trends, innovations and potential opportunities.

10. How likely do you think the adoption of green procurement practices will increase in the Malaysian construction industry over the next 5 years? *

Mark only one oval.

- ◯ Very unlikely
- ◯ Unlikely
- ◯ Neutral
- ◯ Likely
- ◯ Very likely

11. Compared to other countries, how would you rate Malaysia's progress in adopting green procurement practices within the construction industry? *

Mark only one oval.

- ◯ Ahead of other countries
- ◯ On par with other countries
- ◯ Behind other countries

12. How likely is it that your organisation will allocate more resources to green procurement initiatives in the next 5 years? *

Mark only one oval.

- ◯ Very unlikely
- ◯ Unlikely
- ◯ Neutral
- ◯ Likely
- ◯ Very likely

13. How effective do you think current government policies are in encouraging the adoption of green procurement practices in the Malaysian construction industry? *

Mark only one oval.

- ◯ Very ineffective
- ◯ Ineffective
- ◯ Neutral
- ◯ Effective
- ◯ Very effective

14. Do you think more training and resources are required to improve the understanding and implementation of green procurement practices? *

Mark only one oval.

- ◯ Yes
- ◯ No

15. How much impact do you think consumer demand for sustainable practices will have on green procurement in the construction industry over the coming years? *

Mark only one oval.

- ◯ No impact
- ◯ Minimal impact
- ◯ Moderate impact
- ◯ Significant impact

End of Questionnaire Survey.

Thank you very much for participating in this survey.