INVESTIGATING SUSTAINABLE CONSTRUCTION: BENEFITS, CHALLENGES AND STRATEGIES

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

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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

Driving sustainable construction in the Malaysian industry is essential to address growing challenges. The construction sector is one of the largest contributors to carbon emissions, waste generation and resource depletion in Malaysia, which makes sustainability a pressing issue. Although awareness of green practices is increasing, adoption is still limited due to high initial costs, lack of knowledge and restricted access to green products. This study examines sustainable construction in Malaysia by identifying its benefits, assessing the main challenges and analysing strategies that support adoption. A quantitative approach was used through a structured questionnaire distributed to developers, consultants and contractors in the Klang Valley, with 120 valid responses collected. Data were analysed using Cronbach's alpha reliability test, mean ranking, Shapiro-Wilk Test, Kruskal-Wallis test and Spearman's correlation test in SPSS. The findings highlight three main benefits: health improvement, carbon footprint reduction, and waste minimisation. Key challenges include high upfront costs, low consumer awareness and weak policy enforcement. Other than that, the key strategies are increase incentives, improve regulation and policies, and loan with low interest rate. Factor analysis revealed five strategic dimensions: capacity building and innovation, innovative financing and smart delivery, institutional and organisational support, policy and environmental governance, and collaboration and market development. These findings contribute to policy development and industry practice by providing evidence-based recommendations to strengthen sustainable construction adoption. The originality of this study lies in bridging the gap between theoretical sustainability goals and practical applications in Malaysia's construction sector.

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LIST OF SYMBOLS / ABBREVIATIONS

α	Cronbach's alpha reliability coefficient
$\bar{x}$	Mean
σ	Standard deviation
H	Value of Kruskal-Wallis test
ρ	Spearman rank correlation coefficient

BIM	Building Information Modelling
HVAC	Heating, Ventilation, and Air Conditioning
IoT	Internet of Things
IPD	Integrated Project Delivery
SPSS	Statistical Package for the Social Sciences
VOC	Volatile Organic Compounds

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

In recent years, sustainable construction has been growing rapidly worldwide due to the need for resource reduction (Lima *et al.*, 2021). However, it also faces various challenges and issues from managerial, strategic, and operational perspectives. Professor C.J. Kibert defined sustainable construction at the 1st International Conference on Sustainable Construction in 1994 as the creation and responsible upkeep of a healthy environment, guided by resource efficiency and ecological principles (Geng *et al.*, 2017). It refers to the practice of designing, constructing, and operating buildings in an environmentally responsible and resource-efficient manner. It aims to minimise the negative impact of construction activities on the environment while ensuring economic and social benefits.

Despite Malaysia's long-standing environmental policies, the adoption of green practices in the construction industry remains low, with less than 5% of buildings receiving green certification (Masyhur et al., 2024). A comparison of Malaysia's green construction development between 2013 and 2022 is shown below the table. The following statistics illustrating the trend and number of green buildings over the years. The data indicates a declining trend in green building development across the country. While early initiatives and government incentives spurred initial growth, the momentum has not been sustained (Ha, Khoo and Koo, 2023). Several factors may contribute to this slowdown, including high initial costs, limited awareness, and resistance to change within the industry. The lack of mandatory green building regulations means that developers often prioritize fimilar method over sustainability (Ha, Khoo and Koo, 2023). Many projects still rely on conventional construction methods that do not emphasize energy efficiency, water conservation, or environmentally friendly materials. In order to encourage the adoption of green buildings, this downward trend emphasises the necessity of more robust legislative enforcement, larger financial incentives, and expanded awareness campaigns. Reversing this trend requires a change in industrial practices backed by strong laws and incentives if Malaysia is to reach its sustainability targets.

Table 1.1: Numbers of Green Building Project Applied Since Year 2013 to Year 2022

Status	Year									
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022 (Jun)
Applied (A)	119	122	71	61	109	47	70	47	85	39
Registered (R)	110	119	69	53	98	44	66	45	81	38
Certified (C)	82	75	69	42	58	32	59	37	28	28

Source: Ha, Khoo and Koo, 2023.

Sustainable construction starts at the design stage, as this is where critical decisions are made to minimize environmental impact and optimize resource use (Geng *et al.*, 2017). It begins with researching available sustainable materials, as well as considering the building's location and surrounding ecosystem. If sustainable construction efforts begin only in the middle stage, during construction rather than at the design phase, it becomes significantly less effective. By this point, many crucial decisions regarding materials, energy efficiency, and environmental impact have already been set in motion, leaving limited room for meaningful sustainability improvements. While sustainability efforts can still be applied to some extent during construction, such as reducing waste, optimizing material use, and improving energy efficiency on-site (Geng *et al.*, 2017). However, the true impact of sustainable construction is best achieved when sustainability is embedded from the very beginning, during the design stage.

Malaysia has made significant strides in sustainable construction, with numerous buildings recognised for their innovative green designs and eco-friendly features. One of the most notable examples is the Menara Kerja

Raya in Kuala Lumpur, a 37-story government building that has received GBI Platinum and Singapore’s Green Mark Gold certification (Jasspeed Singh *et al.*, 2021). This high-rise incorporates solar panels, an efficient cooling system, and water-saving technologies to reduce both energy and water consumption. Similarly, the Diamond Building in Putrajaya which is another award-winning green building, utilizes an innovative diamond-shaped design to optimize natural lighting and reduce reliance on artificial illumination (Jasspeed Singh *et al.*, 2021). Recognised with an ASEAN Energy Award, this building also features LED lighting, solar panels, and rainwater collection systems to lower its environmental footprint.

1.2 Importance of the Study

With the global push toward sustainability and the growing impact of climate change, the construction industry is increasingly under pressure to adopt practices that reduce its environmental footprint. The importance of the study on Investigating Sustainable Construction: Benefits, Challenges, and Strategies lies in its potential to advance understanding and procedures within Malaysia's building sector. Despite the numerous benefits of sustainable construction, many industry professionals still face challenges in implementing these practices, ranging from financial limitations to a lack of technical expertise. This study also aims to offer practical recommendations that can help overcome barriers and promote the widespread adoption of green building techniques.

1.3 Problem Statement

In today's rapidly growing world, the construction industry are important in urban development and infrastructure expansion. However, it also has significant negative impacts on the environment , while construction is essential for economic growth and societal progress. From deforestation and excessive resource consumption to pollution and carbon emissions, modern construction activities contribute to environmental degradation in various ways. The increasing demand for new buildings, roads, and industrial facilities has led to habitat destruction, air and water pollution, and high levels of waste generation. A recent study from developed nations indicates that the building sector accounts for 30-40% of natural resource consumption, 50% of total energy usage for heating and cooling, almost 40% of global material consumption in the built environment, and 30% of energy demand related to housing (Kamar and Hamid, 2012). As the world strives for sustainable development, it is crucial to address these environmental concerns and implement eco-friendly construction practices to minimize harm to the planet.

According to Kaja and Goyal (2023), the built environment is responsible for 40% of global CO_2 emissions each year. Of this, building operations contribute 27% of total emissions, while the materials and construction of buildings and infrastructure account for an additional 13%. Malaysia currently ranks 30th globally in carbon emissions, highlighting the nation's significant contribution to environmental degradation (Masyhur et al.2024). Carbon dioxide (CO_2) is a colorless, odorless, and non-toxic gas generated through coal combustion and the respiration of living organisms, also as know as greenhouse gas (Zainordin and Zahra, 2021). Emissions refer to the release of greenhouse gases and their precursors into the atmosphere over a specific area and time period. CO_2 emissions primarily result from the burning of fossil fuels and cement production, including carbon dioxide released during the consumption of solid, liquid, and gaseous fuels, as well as from gas flaring (Zainordin and Zahra, 2021). CO_2 traps heat in the Earth's atmosphere (Lindsey, 2024). It will lead to rising global temperatures, climate change, and extreme weather events. Additionally, increased CO_2 levels contribute to poor air quality, which can exacerbate respiratory issues, reduce cognitive function, and indirectly affect human health by worsening heatwaves and spreading infectious diseases.

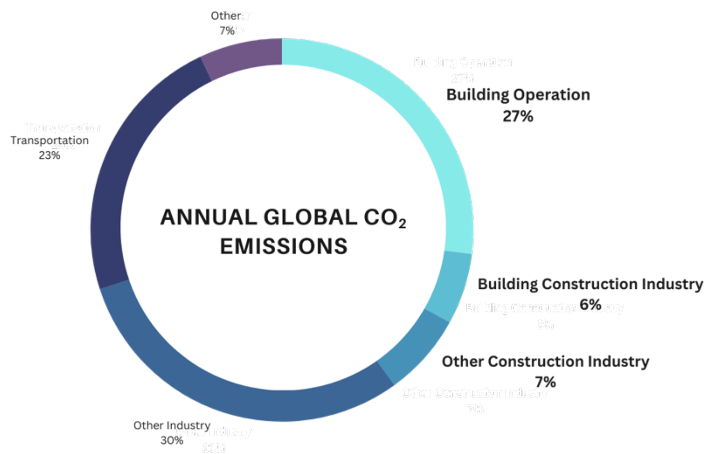

Figure 1.1: Annual Global CO_2 Emissions in 2022
Source: Kaja and Goyal, 2023.

Construction waste has been increasing year by year due to the rapid growth of urbanization and population expansion (Assylbekov et al., 2021). The disposal of excess materials, demolition debris, and unused resources contributes to environmental pollution, land degradation, and excessive landfill use (Assylbekov et al., 2021). Assylbekov has shown that many construction companies lack specific policies for waste reductio. Those with clear policies actively work to minimize waste at the source, such as preventing waste generation during construction. The amount of waste generated from construction activities varies based on factors such as project size, associated tasks, and location. Construction waste can be produced at various stages, starting from site clearing at the beginning of the project and continuing through to the final handover. A survey identified the five main causes of construction waste as design changes, leftover materials, packaging waste, design or detailing errors, and adverse weather conditions (Assylbekov et al., 2021). Refer to Umar, Shafiq and Ahmad (2021), 25,600 tons of construction and demolition waste are produced daily. If not properly managed the construction waste, it can lead to severe ecological consequences, including soil and water contamination.

Buildings account for up to 40% of global energy consumption, and this figure is projected to rise to 50% by 2030 (Hassan *et al.*, 2014). In Malaysia, buildings are responsible for 48% of the country's total electricity consumption, highlighting the significant energy demand of the construction and building sector(Hassan *et al.*, 2014). It is high energy demands for activities such as material production, transportation, and on-site operations. Fossil fuels is one of the primary sources of global electricity and heat (Qu *et al.*, 2017). Hassan et al.stated that by 2020, Malaysia's energy demand was projected to reach 116 million tons of oil equivalent (Mtoe), reflecting the country's growing energy consumption driven by urbanization, industrial expansion, and infrastructure development. The burning of fossil fuels for energy production releases greenhouse gases like carbon dioxide (CO_2), which trap heat in the atmosphere and cause global warming (Qu *et al.*, 2017).

This leads to rising temperatures, extreme weather events, and disruptions to ecosystems.

Construction industry need more sustainable to minimise its environmental impact and promote long-term ecological balance. Most studies focus on benefits and challenges, but do not suggest comprehensive, actionable methods for boosting sustainable construction adoption, particularly in terms of industry collaboration and smart technology. Incorporating smart technologies like IoT, BIM, and modular prefabrication into the sustainability roadmap brings a modern, technology-driven approach to traditional construction methods. This research aims to analyze the benefits, challenges, and strategies of sustainable construction. By exploring these aspects, the study seeks to contribute to the development of greener construction methods that balance economic growth with environmental protection.

Previous studies on sustainable construction have provided useful insights but also show several limitations. For instance, Kamar et al. (2010) and Zainordin and Zahra (2021) focused mainly on environmental performance and green technologies, neglecting social and economic perspectives. Shafiq et al. (2020) examined sustainability implementation barriers but did not explore potential strategies to overcome them. Hassan et al. (2014) highlighted energy efficiency issues but analysed only technical aspects. These studies, though valuable, were often based on small samples, involved only limited stakeholder groups, or focused on single dimensions of sustainability. Few studies have examined the combined relationship between the benefits, challenges, and strategies of sustainable construction within the Malaysian context. Therefore, this study aims to fill these gaps by conducting an integrated analysis of sustainable construction practices from the perspectives of developers, consultants, and contractors in Malaysia. It seeks to explore how different stakeholders perceive the benefits, challenges, and strategies of sustainable construction and to identify interrelationships among these dimensions to support more effective sustainability adoption in the industry.

1.4 Research Aim and Objectives

The aim of this research is to examine how sustainable construction is being implemented in Malaysia's construction industry by analysing its benefits, identifying the challenges faced, and evaluating the strategies that support its adoption. To achieve the research aim outlined above, the following research objectives have been defined:

i. To identify the benefits of sustainable construction in Malaysia's construction industry.
ii. To investigate the challenges of sustainable construction in Malaysia's construction industry.
iii. To appraise the strategies for adopting sustainable construction in Malaysia's construction industry.

1.5 Research Question

1. What are the key environmental, economic, and social benefits of adopting sustainable construction practices in Malaysia's construction industry?
2. What are the major challenges hindering the implementation of sustainable construction in Malaysia?
3. What strategies can be effectively implemented to promote the widespread adoption of sustainable construction practices in Malaysia?

1.6 Research Scope and Limitation of the Study

This research focuses on the sustainable construction industry in Klang Valley, Malaysia. Data for the study were collected from professionals such as architects, engineers, and quantity surveyors working in the region. By gathering insights from these key stakeholders, the research aims to explore the current practices, challenges, and opportunities for promoting sustainability within the sector.

1.7 Research Methodology

This study used a quantitative research methodology to meet its objectives. It allowed data to be collected in a structured way and analysed statistically. A questionnaire created using Google Forms served as the main data collection tool. This platform enabled easy distribution and quick access for respondents. The questionnaire was shared through email and various social media platforms to boost the response rate. Google Forms offered several advantages. It was easy to use, supported automatic data collection, and allowed real-time tracking of responses. It also enabled anonymous participation which helped reduce bias and encouraged honest answers. The structured format of the questionnaire ensured consistency in responses. This made the data easier to analyze accurately.

1.8 Outline of the Report

This research report is divided into five chapters: Introduction, Literature Review, Research Methodology, Results and Discussion, and Conclusion and Recommendations.

Chapter 1: Introduction

Describes the background and problem statement of the sustainable construction in Malaysia. This chapter also includes the aim and objectives of the study, the contribution of the study, and a chapter outline to guide the reader through the structure of the report. The research scope is limited to construction professionals as respondents, specifically architects, engineers, and quantity surveyors, who provide insights into sustainable construction practices in Malaysia.

Chapter 2: Literature review

This chapter consists of a literature review on previous research regarding sustainable construction, including its methods, benefits, and challenges. In addition, this chapter will discuss the key concepts, theories, and frameworks related to sustainable construction.

Chapter 3: Research Methodology

This chapter outlines the research methodology that will be used to achieve the aim and objectives of this study. This includes a detailed description of the data collection and analysis methods, as well as the rationale behind the design of the questionnaire surveys. The chapter will explain how the data will be gathered from construction professionals and how the responses will be analysed to address the research questions effectively.

Chapter 4: Result and Discussion

This chapter presents the results of the study, which consist of data gathered through questionnaires. The data will be systematically organised and presented in tables and charts to fulfill the research aims and objectives.

Chapter 5: Conclusion and Recommendation

Chapter 5 will conclude the study by summarizing its results and findings. It will also present recommendations and limitations, offering insights for the improvement of future related research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, a comprehensive review of published journals and articles on sustainable construction by researchers from various disciplines is presented. The chapter starts with a definition of sustainable construction, on the basis of which its concepts are grounded. Then, it will bring about the various advantages of sustainable building by analyzing the past studies that have already been done and discussing them. This will be followed by the organization discussing the current issues that are preventing the building of sustainable practices in the construction sector at a global level. In the end, some tactics will be put forward for making use of sustainable construction in order to provide helpful ideas on applying them effectively in the future.

2.2 Definition

Table 2.1: Definition of Sustainable Construction

Terms	Definitions	Authors
Sustainability	"Sustainability primarily refers to the conservation of natural resources, the protection of biodiversity, the minimization of environmental risks, and the pursuit of a balanced relationship between human development and environmental stewardship."	Damico, Aulicino and Di Pasquale (2022, pp.14)
Sustainable Construction	"Sustainable building ensures that all construction activities, from planning to completion, are carried out in a sustainable manner, taking into account economic, social, and environmental issues."	Willar et al. (2021, pp. 106)

According to Coursera (2025), the goal of sustainability is to forecast and pursue the development path that will be beneficial for the environment, society, and the economy and one that will help achieve long-lasting sustainability. However, it goes further by just conserving nature and its diverse ecosystems. It simultaneously proposes growing enterprises and local government, which will ensure that all sectors function harmoniously through cooperation. The main purpose is to protect, preserve, and enhance the natural environment, which is among the key ingredients for a healthy and sustainable world in the future.

Willar et al. (2021) stated that "sustainable construction is a way of ensuring that all construction activities are being carried out in a sustainable manner from the planning stage through to the execution stage, with consideration to the economic and social aspects and the environmental effects." This suggests that sustainable construction is an indigent activity that attempts to incorporate green construction by making it a part of the project's phases from inception to finish, not merely using green materials or cutting waste.

2.3 Benefit of Sustainable Construction in Malaysia’s construction industry

2.3.1 Environmental Benefits

2.3.1.1 Energy Efficiency

First of all, one of the benefits of sustainable construction is energy efficiency, which significantly reduces energy consumption (Reddy, 2016). According to Hafez et al. (2023), sustainable buildings incorporate active and passive design strategies to achieve energy efficiency. Active design converts energy into electrical power using technology like wind turbines, solar panels, and heat collection devices. In contrast, passive design utilises "unpowered" natural systems to supply ventilation and heating or cooling for the environment (Ardyanny, 2022). The passive design includes optimal building orientation, natural ventilation, daylight utilisation and so on. For example, by integrating passive design strategies, sustainable construction significantly enhances energy efficiency using daylight utilisation. Daylight utilisation works through skylights and large windows to reduce the need for artificial lighting and lowering electricity consumption (Ardyanny, 2022).

Sustainable construction also promotes the integration of renewable energy sources. Renewable energy sources are solar panels, wind turbines, and energy-efficient cooling systems, which are part of active design strategies (Ardyanny, 2022). For instance, for the cooling system, water-cooled chillers are more efficient than air-cooled chillers for cooling systems due to water's higher heat capacity (Ardyanny, 2022). At the same time, air-cooled chillers use air to cool the condenser and are suitable for areas with water scarcity or high humidity. Water-cooled chillers utilise water for condenser cooling resulting in greater efficiency. Their superior heat transfer capabilities make them a more energy-efficient choice in most climates (Ardyanny, 2022).

Since heating and cooling demand the most electricity, passive design techniques allow us to maintain thermal comfort inside a building without using electricity. Supply electricity from renewable energy sources is the ways that active design methods can help reduce energy usage. As a result, the building can achieve its highest level of energy efficiency, leading to low operational costs and reducing environmental impact due to lesser fossil fuel being burned. (Hafez *et al.*, 2023).

2.3.1.2 Water Efficiency

With proper management, water may be a renewable resource and a significant restricted resource for human welfare. EL-Nwsany, Maarouf and Abd el-Aal (2019) stated that they help strengthen the economic, social, and environmental systems' ability to withstand rapid and unforeseen change when water resources are managed well. Sustainable construction promotes water efficiency through strategies like rainwater harvesting systems, using water-efficient fixtures, and implementing greywater recycling to reduce buildings' water consumption (Assylbekov et al., 2021). Rainwater harvesting system where collected rainwater is stored and reused for non-potable purposes like irrigation, flushing toilets, and cooling systems. Similarly, greywater recycling repurposes wastewater from sinks, showers, and laundry for landscaping or other non-drinking purposes to further reduce freshwater demand. According to Teston et al. (2022), rainwater-harvesting systems typically consist of a catchment surface, distribution pipes, storage tanks, and complementary devices for water quality control. The building's roof serves as the catchment surface, directing rainwater into storage tanks via pipes and motor pumps. When storage capacity is exceeded, excess water is diverted to urban collection systems or infiltration ditches. First-flush diverters, solids removal filters, and fine filters help reduce contaminants and minimise exposure to pathogens to ensure water quality (Teston *et al.*, 2022). These systems support net-zero water buildings by providing an alternative water source, making them especially beneficial for water-stressed cities (Teston *et al.*, 2022).

Beyond conserving water, effective water management also reduces carbon emissions from water heating and pumping, utility costs, and the energy required for water treatment and distribution (Teston *et al.*, 2022). Sustainable buildings reduce water waste, increasing resistance to droughts and water scarcity and guaranteeing a more sustainable future.

2.3.1.3 Waste Reduction

Ha, Khoo and Koo (2023) mentioned that eight million tonnes of construction trash are created as a result of construction activity every year. The construction industry is a major contributor to waste generation, but sustainable practices help mitigate this issue. Sustainable construction focuses on precise material estimation, prefabrication, and modular construction to minimise excess waste. Resources that are utilised effectively through efficient planning can lead to reducing material leftovers and lowering landfill contributions(Mohammed *et al.*, 2021). Building Information Modeling (BIM) and construction management software can be used to calculate the exact amount of materials needed, reducing leftover materials that would otherwise end up in landfills . Beyond making correct material requirements forecasting, more demand is also avoided and the company reduces the waste. Off-site prefabrication requires building parts such as walls, floors, and structural elements to be produced in a factory-controlled environment and then transferred to the construction site for assembly (Mohammed *et al.*, 2021). This technique of optimising cuts and minimising on-site errors reduces fabric waste and improves efficiency. Prefabrication is also known to be improved in terms of quality and will reduce energy consumption during construction. Furthermore, modular construction is the assembling of the sections of the building that are made beforehand, which gives these small parts the chance to be reused or repurposed in future projects. Since these modules are made with precision and there are no extra materials wasted, it shows an extremely low level of material waste (Mohammed *et al.,* 2021). It is the one that can be demolished or relocated. At the same time, the aspect that makes them more sustainable as compared to conventional construction.

2.3.1.4 Reduce Carbon Footprint

Sustainable construction plays a crucial role in lowering carbon emissions. Sizirici et al. (2021) discovered that buildings in both developed and developing nations are responsible for 40% of worldwide energy consumption and 33% of greenhouse gas (GHG) emissions, which are caused by equipment use, construction material production, and transportation. There are various ways to lower the carbon footprints of construction. Most of the energy we use today comes from burning fossil fuels such as coal, oil, and natural gas. When these fuels are burned to generate electricity or power machines, they release carbon dioxide (CO_2) into the atmosphere. Passive design methods can significantly reduce the demand for fossil fuels by minimizing the need for mechanical heating, cooling, and lighting in buildings. The use of solar panels, wind turbines, and geothermal energy helped to limit the demand for fossil fuel energy (Sizirici *et al.*, 2021).

Additionally, using low-carbon materials, a way of sustainable construction significantly reduces the environmental impact of raw material extraction and production (Sizirici *et al.*, 2021). The new low-carbon materials are steel, concrete, and bamboo. They are also known as green materials. Steel production in its conventional way requires heavy mining processes, energy consumption, and results in releasing a significant amount of CO_2 emissions. Meanwhile, recycling steel lines the path of metal relocation, the level of mining will decline, so will the energy consumption by up to 75%, compared to producing virgin steel (Sizirici *et al.*, 2021). The plan ahead concrete blends reused materials, like fly ash from coal combustion, slag, and silica fume, in both the fine and coarse aggregates. This drastically reduces the use of traditional Portland cement, which is known as a major carbon emission contributor worldwide. Cement production creates roughly 8% of the global CO_2 emissions. Thus, green concrete notably diminishes this footprint by means of using industrial by-products and possessing low-energy requirements (Sizirici *et al.*, 2021).

In this way, sustainable construction companies not only achieve the ultimate objective of reducing greenhouse gas emissions and mitigating climate change, but they also contribute to the establishment of healthy living environments. Constructing buildings that include natural ventilation, non-toxic materials, and improved air quality leads to the general improvement of the occupants' health, as harmful pollutants will be minimized.

2.3.1.5 Better Use of Materials

Sustainable construction places a strong emphasis on material reuse and recycling to reduce environmental impact (Kralj and Markič, 2008). Instead of discarding materials from demolished structures, valuable components such as wood, steel, concrete, and glass can be salvaged, repurposed, or recycled for new construction projects. It is acknowledged that reuse and recycling are different in both philosophy and how the resources that this special industry removes from the waste stream are handled. Because they gather, separate, process, and manufacture their acquired things into new products, recyclers have been successful in keeping materials out of landfills (Kralj and Markič, 2008). Many reuse programs have emerged as part of waste reduction efforts, as reuse requires fewer resources, energy, and labour compared to manufacturing new products (Kralj and Markič, 2008). It serves as an environmentally preferred waste management method, helping reduce pollution and the demand for natural resources like timber and petroleum. For example, old concrete from demolished buildings is crushed and reused as an aggregate in new concrete mixes, also known as recycled concrete aggregate. It is reducing the demand for virgin materials and minimizing construction waste.

2.3.2 Social Benefits

2.3.2.1 Health Improvement

Chandra (2015) identified that green building sustainability not only leads to the erection of clean air but also develops a healthier surrounding. The quality of air in sustainable construction projects increases as there are fewer carbon emissions and less indoor pollution (Chandra, 2015). By putting in place energy-saving and waste-generation strategies, sustainable building options become critical in reducing carbon footprint and enhancing air quality in buildings. Low-VOC paints are a good approach to improving air quality. According to Adamkiewicz (2010), low-VOC paints are another example of a sustainable material which helps to minimize the environmental impact and improve indoor air quality. VOCs, which are the most common component in conventional paints, remain air pollutants and are hazardous to human health. When using low-VOC paints, the aim is for the health of the environment and the building occupants in the presence of fewer bad chemicals in the paint (Adamkiewicz, 2010).

Thus, air pollution will cause one to acquire diseases such as asthma, bronchitis, and lung infections. A few common effects of increased CO_2 concentrations indoors are fatigue, headaches, dizziness, and a drop in concentration. Exposure to indoor pollutants and allergens, which weaken the immune system, increases the likelihood of acquiring an infection. As a result, high-quality air is one of the key factors in people's health and the well-being of communities.

2.3.2.2 Increased productivity, Staff Recruitment and Retention

There are numerous reasons why sustainable construction is non-exclusively beneficial to the environment and low-cost operation, as it also increases workplace efficiency, productivity, staff recruiting, and employee retention (Miller *et al.*, 2009). Green buildings are the ones that develop healthier and more relaxed working environments, which form the basis for higher job satisfaction and overall health. The productivity level of employees is determined by the work environment they operate in (Miller *et al.*, 2009). Designed and run thoughtfully, a workspace can greatly boost employee results. Natural lighting, better air quality, ergonomic working conditions, as well as noise-proofing for a quieter and more stimulating workspace, contribute to a more pleasant environment. Studies have shown that employees under the green certification program operate with fewer episodes of sick calls, concentrative ability, and optimal cognition. This leads to higher efficiency and output (Miller *et al.*, 2009).

Organizations that opt to create environmentally friendly offices attract top-tier talents that have a preference for environmental conservation and social giving (Miller *et al.*, 2009). Nowadays, employees, especially millennials and Gen Z, favor workplaces that expose them to the values of preservation and prosperity. The principle of green building will evoke interest among job seekers. These help companies in recruitment competition. Apart from that, the biodiversity, which also increases job satisfaction and lowers turnover rate, is another contribution of sustainable workspace (Miller *et al.*, 2009). A work environment positively affects mental health, especially through clean air, atmospheric ventilation, and the outdoor area. Consequently, the well-being of the staff members increases, and job satisfaction improves. Workers who operate in comfortable, eco-friendly offices with company policies on work-life balance tend to remain in the same companies as those who do not.

2.3.2.3 Enhance Comfort Condition inside the Building

According to Hoxha and Shala (2019), increased comfort conditions inside the building is a social benefit of sustainable construction. Sustainable buildings are designed with features that improve thermal comfort, air quality, natural lighting, and acoustics (Hoxha and Shala, 2019). The use of eco-friendly materials and smart building systems helps regulate indoor temperatures and reduce humidity. Sustainable building also maintain good ventilation. These factors contribute to a healthier and productive indoor environment, ultimately improving the well-being and satisfaction of occupants (Hoxha and Shala, 2019). For example, high-performance insulation, energy-efficient glazing, and green HVAC systems help maintain consistent indoor temperatures with minimal energy use. Natural lighting through optimised window placement reduces the need for artificial lighting while supporting occupants' circadian rhythms. Furthermore, low-VOC (volatile organic compounds) materials contribute to better indoor air quality, which reduces health risks and enhances overall comfort.

2.3.3 Economic Benefits

2.3.3.1 Lifecycle Cost Reduction

According to Jackson (2023), sustainable building cuts lifecycle costs by focusing on long-term savings instead of just initial costs. Sustainable buildings may cost more upfront to buy eco-friendly materials and technologies. However, they save a lot of money in the long run because they use less energy, need less maintenance, and last longer. As mentioned earlier, sustainable buildings incorporate energy-efficient lighting and insulation to reduce electricity and heating costs (Jackson, 2023). The use of renewable energy sources helps lower reliance on grid electricity and results in long-term savings. Beyond energy efficiency, implementing rainwater harvesting, greywater recycling, and water-efficient fixtures reduces water consumption and lowers utility bills. Over time, it cut costs even more. After that, sustainable building also uses high-quality materials that last a long time, like recycled steel, bamboo, and low-carbon concrete, so it doesn't have to be fixed or replaced as often. This means that building owners and residents will have lower upkeep costs over the life of the building (Jackson, 2023). According to Jackson (2023), green-certified houses often have higher resale value and demand. People who are willing to pay more for green and energy-efficient places are interested in it. When businesses rent eco-friendly buildings, their running costs go down, and their brand's reputation goes up. Zhou and Lowe (2003) mentioned that sustainable construction saves money in the long run, so it's a good investment for both building owners and people who live in the building.

2.3.3.2 Increase the Property Value

Sustainable construction is a way of increasing the property value through some features that meet the desires of potential customers (Zeller, 2025). Apart from its long-term cost savings, the building would also have improved indoor air quality and be extremely ecologically friendly. Being certified as a LEED (Leadership in Energy and Environmental Design), ENERGY STAR or BREEAM (Building Research Establishment Environmental Assessment Method) property adds more value (Zeller, 2025). Such certifications help establish a third-party certified comparison between the property and its sustainability traits, resulting in a more active buyer or investor pool. Among the most prominent factors for buyers of real estate properties are energy efficiency, robustness, and easier maintenance. These green-certified properties in the real estate market have become significant due to the fact that they only appeal to eco-conscious buyers who prioritise these things.

Government incentivisation, such as tax rebates or grants, and financial assistance for energy-efficient upgrades also amplify the attraction of sustainable property (My HIJAU, 2024). These financial benefits make green-certified buildings more attractive to buyers. This leads to increased demand and, consequently, higher market value.

Moreover, properties located in sustainable communities often experience greater appreciation in value. Sustainable communities are the places that prioritise green spaces, walkability, and access to public transportation. Such developments make our lives easier by providing alternatives to automobiles, lowering vehicle traffic, enhancing air quality, and ensuring healthful living environments. Accessibility to parks, cycling paths, as well as locally owned businesses would create desirability and thus increase the market value of the properties for sustainability. Therefore, sustainable construction not only reduces operating expenses but promotes a better market position, appeals to the premium market niche, and receives the financial incentives that should let the building owners reap financial benefits.

Table 2.2: Literature Map for Benefis of Sustainable Construction in Malaysia’s Construction Industry

Ref	Benefit	Ahiabu, Emuze and Das (2023)	Baloi (2003)	Firoozi et al. (2025)	Ha, Khoo and Koo (2023)	Hoxha and Shala (2019)	Liu et al. (2020)	Assylbekov et al. (2021)	Reddy (2016)	Sizirici et al. (2021)	William Dobson et al. (2013)	Zhou and Lowe (2003)	Total
	Environmental Benefits												
1	Reduce Carbon Footprint	✓	✓	✓	✓	✓		✓	✓	✓	✓		9
2	Energy Efficiency	✓		✓		✓	✓	✓	✓		✓	✓	8
3	Waste Reduction	✓	✓	✓	✓			✓	✓	✓			7
4	Water Efficiency	✓	✓			✓		✓	✓			✓	6
5	Better Use of Materials			✓	✓			✓					3

Table 2.2: Literature Map for Benefis of Sustainable Construction in Malaysia's Construction Industry

Ref	Benefit	Ahiabu, Emuze and Das (2023)	Baloi (2003)	Firoozi et al. (2025)	Ha, Khoo and Koo (2023)	Hoxha and Shala (2019)	Liu et al. (2020)	Assylbekov et al. (2021)	Reddy (2016)	Sizirici et al. (2021)	William Dobson et al. (2013)	Zhou and Lowe (2003)	Total
	Social Benefits												
1	Health Improvement	✓				✓	✓	✓	✓				5
2	Increased productivity, Staff Recruitment and Retention		✓		✓	✓			✓			✓	5
3	Enhance Comfort Condition inside the Building	✓				✓					✓		3
	Economic Benefits												
1	Lifecycle Cost Reduction		✓		✓	✓		✓			✓	✓	6
2	Increase the Property Value						✓		✓				2

2.4 Challenges of Sustainable Construction in Malaysia's construction industry

2.4.1 Weak Policy Enforcement

According to Ha, Radzi and Khoo (2020) and Kamar and Hamid (2012), another barrier to sustainable construction in Malaysia is the weak enforcement of sustainability-related policies and regulations. The push for greener construction becomes less effective when there is no strong policy support or solid government backing (Wong *et al.*, 2021). This lack of enforcement not only limits participation from the construction sector but also slows down the growth of the green construction market in Malaysia. To support sustainable construction, both clear policies and financial help are needed. These can encourage more industry players to get involved and help reduce the costs of adopting environmentally friendly practices (Wong *et al.*, 2021). Furthermore, Malaysia has introduced frameworks like the Green Building Index (GBI) and the Construction Industry Transformation Programme (CITP). However, since these frameworks are voluntary and not applied consistently across different areas, they are less effective in promoting widespread change (Wong *et al.*, 2021). Many developers and contractors are reluctant to fully engage in green building practices due to the absence of clear and enforced regulations, as well as the perceived additional costs involved. The lack of strong policy enforcement means that even when sustainable construction practices are encouraged, there is little accountability for non-compliance. This results in a slow uptake of green technologies and sustainable practices, preventing Malaysia from reaching its full potential in sustainable development.

2.4.2 Lack of Knowledge on Sustainable Construction

Many significant stakeholders are inherently resistant to change because they are unaware of the importance of sustainable building. Therefore, the biggest obstacle is a lack of understanding of the necessity of sustainable design (Kamranfar *et al.*, 2023). However, many professionals are also unfamiliar with sustainable practices and the application of sustainable materials. Those professionals include contractors, designers, engineers and workers. This can lead to confusion and poor decision-making when applying sustainable practices (Kamranfar *et al.*, 2023). They will resist adopting new green practices and relying on traditional methods. For instance, some project teams did not understand the requirements of GBI and LEED which make the building standard more sustainable. They also may not understand how to choose sustainable building materials and how to design them in an energy and water-efficient way. Without proper knowledge, they might resist change due to fear of higher costs, unforeseen risks and technical difficulties. These knowledge gaps will increase construction mistakes, delay the construction process, and reduce the quality of the building.

2.4.3 Low Consumer Awareness

According to Shafii, Arman Ali and Othman (2006), low consumer awareness is one of the challenges of sustainable construction. They stated that the construction industry is still getting used to the idea of sustainability in developing countries (Shafii, Arman Ali and Othman, 2006). Many homebuyers and investors are either unaware of the benefits of green buildings. It leadswill to slower market demand as consumers are likely to make decisions based on immediate cost rather than long-term value (Shafii, Arman Ali and Othman, 2006). For example, many potential consumers are unaware that green building can offer long-term cost savings due to reduced energy and water consumption. Moreover, the health benefits that green buildings bring are more than we know, such as improved air quality, which can increase our productivity and comfort. As another assumption, they believe that green buildings are too expensive to manage (Shafii, Arman Ali and Othman, 2006). The likelihood of developers developing or investing in sustainable buildings in the future is reduced as a result of these variables. Developers will likely rely on traditional methods to minimize risk and have a fast return.

2.4.4 Lack of Training and Skilled Labour

Durdyev et al. (2018) stated that workers in developing countries, including Malaysia, lack proper training and skills for sustainable construction. This shortage of trained and skilled labour is a significant barrier to the implementation of sustainable construction practices. Sustainable construction involves specialised knowledge and skills, especially in the use of energy-efficient technologies, sustainable construction methods, and eco-friendly materials. These techniques and technology are often not widely available within the existing workforce. This is because many construction professionals and workers may not necessarily have formal education or training in sustainability in the construction industry. Thus, this deficit hampers the industry's power to cope with the demands of green construction projects (Durdyev *et al.*, 2018). The absence of comprehensive training programs and certification opportunities for construction workers further exacerbates this challenge. Without the proper skills and knowledge, workers may struggle to implement sustainable construction practices effectively (Wong *et al.*, 2021). This may lead to inferior craftsmanship, resulting in buildings that do not adhere to sustainability requirements or exhibit deficiencies in energy efficiency, durability, and environmental effect. Moreover, a lack of skilled labour can lead to inefficient construction processes. Inexperienced workers may require more time to complete tasks, leading to delays and cost overruns. Errors caused by inadequate knowledge of sustainable materials and techniques can result in rework, further increasing project costs.

2.4.5 Lack of Professional Capabilities or Designers

The lack of skilled professionals and designers is another problem in sustainable construction in Malaysia (Shafii, Arman Ali and Othman, 2006). Many architects, engineers, and consultants do not have enough knowledge about green building design. The knowledge and skills needed for sustainability take significant time to learn and apply effectively in design processes (Shafii, Arman Ali and Othman, 2006). This complexity highlights a clear gap in the current educational and training frameworks. Most professionals are still more familiar with conventional construction methods, which limits their ability to design buildings that are energy-efficient or make use of eco-friendly materials (Shafii, Arman Ali and Othman, 2006). As a result, it becomes difficult to plan and execute sustainable projects. Even if the developer wants to build a sustainable project, they may not find the right people to help. Some professionals also do not keep up with the latest green technologies. This slows down the growth of sustainable construction.

2.4.6 High Initial Cost

The higher initial cost is one of the main challenges of sustainable construction compared to traditional methods (Djokoto, Dadzie and Ohemeng-Ababio, 2014). Several factors contribute to the increased initial cost, including labour costs, the cost of sustainable materials, and design-related expenses. Sustainable construction requires workers with specialised skills and knowledge. This demand often leads to higher wages for skilled labour. It also adds extra costs for training and certification (Sunbase, 2025). Unlike traditional construction, green building methods require workers to understand innovative technologies and materials. For example, the installation of a complex geothermal heating and cooling system demands technicians with specific training in underground piping, heat exchange systems, and system calibration (Sunbase, 2025).

Some sustainable materials are more expensive than conventional ones, such as self-healing concrete, recycled steel, cross-laminated timber (CLT), and low-VOC (volatile organic compound) paints. This is because of the use of raw materials and complex production processes. For example, cornflour and cassava are the natural raw materials used to make biodegradable plastic (Bailey, 2024). Compared to petroleum-based components used in traditional plastic production, these resources are more costly (Bailey, 2024). The cost of biodegradable plastic products rises overall as a result of the higher raw material costs being passed on throughout the production process.

Design-related expenses in sustainable construction can be higher than in traditional projects. This is because sustainable projects often include both active and passive design strategies to improve energy efficiency and comfort. These strategies require careful planning and sometimes custom building shapes, which can increase design time and costs.

2.4.7 Lack of Financial Incentives

Lack of financial incentives and support from the government are the barriers to sustainable construction in Malaysia's construction industry (Okoye, Okolie and Odesola, 2022; Eze, Sofolahan and Omoboye, 2023; Osuizugbo *et al.*, 2020). To develop or implement new technology and techniques, a country or a company needs incentives. If the construction industry does not maximize its understanding and deficiency in the green development stage, there will not be much impact on the incentives. Due to sustainable building practices requiring eco-friendly materials, innovative technologies, and adherence to green certification standards, they frequently have greater upfront expenditures (Eze, Sofolahan and Omoboye, 2023). Many developers and contractors are reluctant to participate in these techniques without the right financial support, such as grants, tax incentives, or low-interest loans, particularly when there is no promise of rapid financial benefits (Eze, Sofolahan and Omoboye, 2023). Although the Malaysian government has introduced some financial incentives to promote sustainable construction, the overall support remains limited and insufficient to drive widespread adoption (Masyhur *et al.*, 2024). These incentives often fall short of covering the high initial costs associated with green materials, energy-efficient technologies, and certification processes like the Green Building Index (GBI) (Masyhur et al., 2024).

2.4.8 Resistance to Change

Resistance to change is a big barrier to sustainable construction in Malaysia (Djokoto, Dadzie and Ohemeng-Ababio, 2014; Osuizugbo et al., 2020). Many people in the industry still prefer the old ways of building. This includes developers, contractors, consultants, and clients. They are accustomed to conventional construction methods and are often hesitant to adopt new, unfamiliar sustainable practices. This resistance may stem from a fear of increased costs, uncertainty about new technologies, lack of understanding of green building benefits, or simply a reluctance to deviate from long-standing habits and systems. In some cases, some professionals believe that using new methods in construction is risky. They think it is not necessary if there is no clear profit. Moreover, the lack of exposure to successful green projects and limited training opportunities only reinforces this resistance. Such mindsets slow the industry's progress toward sustainability despite growing environmental concerns and global pressures for greener development.

2.4.9 Sustainable Materials Supply Chain Limitation

Sustainable materials supply chain limitation can be identified as a crucial challenge of sustainable construction in Malaysia's construction industry(Casandra Okogwu *et al.*, 2023). In certain areas, sustainable resources like bamboo, low-carbon concrete, recycled steel, and other similar materials are not readily available in large quantities. Particularly in underdeveloped nations, there is comparatively little manufacture of sustainable materials. The building industry finds it more difficult to implement sustainable methods due to this limited supply widely. This often leads to a reliance on costly imports and increases the overall construction cost (Casandra Okogwu *et al.*, 2023). The supply chain also has uncertainties when importing sustainable materials to a country. Additionally, importing materials to the construction sites involves a long delivery time. This may lead to delays in construction progress, especially if shipments are disrupted due to customs, weather, or logistic issues. For big projects, even small delays in getting materials can throw off building schedules in a big way. Casandra Okogwu et al. (2023)discovered that sourcing that material from a distant supplier may increase the carbon footprint due to long transportation distances, potentially conflicting with sustainable development goals.

2.4.10 Long Payback Periods from Sustainable Practices

Osuizugbo et al. (2020) studied sustainable construction in long payback periods associated with sustainable practices. Although sustainable technologies offer long-term operational savings and environmental benefits, the initial investment costs are often high. For many developers and clients, the return on investment (ROI) from these green features may take years to materialize (Levy, 2023). Research by the Green Building Council shows that a payback period of even three to five years can actually bring back the costs for green building (Levy, 2023). This extended pay-back period can be a deterrent, particularly in a market driven by short-term financial gains and cost-efficiency. In some cases, project stakeholders may measure immediate profitability as a priority instead of considering long-term sustainability, especially when the budget is tight or financing options for green upgrades are hard to get. The situation is further compounded by a lack of awareness among property buyers about the long-term benefits of sustainable buildings, which reduces market demand and discourages developers from investing in eco-friendly features.

Table 2.3: Literature Map for Challenges of Sustainable Construction in Malaysia’s Construction Industry

Ref	Challenges	Casandra Okogwu et al. (2023)	Djokoto, Dadzie and Ohemeng-Ababio (2014)	Durdyev et al. (2018)	Eze, Sofolahan and Omoboye (2023)	Ha, Radzi and Khoo (2020)	Ifije and Aigbavboa (2020)	Kamar and Hamid (2012)	Kamranfar et al. (2023)	Ogunsanya et al. (2022)	Okoye, Okolie and Odesola (2022)	Osuizugbo et al. (2020)	Serpell, Kort and Vera (2013)	Shafii, Arman Ali and Othman (2006)	Wong et al. (2021)	Zulu et al. (2023)	Total
1	Weak Policy Enforcement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		14
2	Lack of Knowledge on Sustainable Construction		✓		✓	✓	✓	✓	✓		✓	✓	✓			✓	10
3	Low Consumer Awareness		✓		✓		✓		✓	✓	✓	✓		✓	✓	✓	10
4	Lack of Training and Skilled Labour		✓	✓	✓	✓		✓	✓			✓		✓	✓	✓	10
5	Lack of Professional Capabilities or Designers		✓	✓	✓				✓		✓	✓		✓		✓	8
6	High Initial Cost	✓	✓	✓	✓						✓	✓			✓		7
7	Lack of Financial Incentives		✓	✓	✓	✓						✓	✓			✓	7
8	Resistance to Change	✓	✓		✓	✓						✓			✓	✓	7
9	Sustainable Materials Supply Chain Limitation	✓			✓					✓	✓			✓		✓	6
10	Long Payback Periods from Sustainable Practices			✓							✓	✓			✓	✓	5

2.5 Strategies for Adopting Sustainable Construction in Malaysia's construction industry

2.5.1 Increase Incentives for Sustainable Construction

To accelerate the adoption of sustainable construction practices in Malaysia, it is crucial to increase governmental and financial incentives (Ma, 2023; Chew, 2010; Chan, Darko and Ameyaw, 2017). Many developers are discouraged by the perceived high initial costs of green building technologies and materials. These expenses can discourage investment, particularly when there are no obvious rewards right away. By introducing targeted incentives, Malaysia can make sustainable construction more economically viable and attractive. The government can offer corporate tax deductions to developers who design and construct buildings according to the standard GBI-certified (Green Building Index) or LEED-certified (Chan, Darko and Ameyaw, 2017). An example from a neighbouring country, Singapore, the Green Mark Incentive Scheme (GMIS) of the Building and Construction Authority (BCA) offers monetary or gross floor area (GFA) incentives to promote the use of eco-friendly construction technology and design techniques, such as those building that improve energy efficiency (BCA, 2005).

2.5.2 Increase the Awarness of Sustainable Construction For Public

Increasing public awareness of sustainable construction is essential to creating widespread support and demand for environmentally responsible building practices in Malaysia (Idris, Ismail and Hashim, 2015). To begin with, public awareness campaigns can be conducted through mass media, social media platforms, exhibitions, and community outreach programs to inform people about the concept and advantages of sustainable construction. Apart from these, these campaigns highlight how such buildings can decrease energy and water bills, improve air quality, and create healthier living spaces.

Educational institutions, such as schools and universities, should include topics on sustainable construction in their curriculums. This will help young people understand the importance of environmental values and build a culture that supports sustainability from an early age. In addition, public events like seminars, green building tours, and open days at certified green buildings can give people real-life examples of how sustainable design works.

Government agencies and local councils can also support green education through community programs (Idris, Ismail and Hashim, 2015). They can encourage residents to follow green practices such as separating waste, collecting rainwater, and saving energy. Working together with influencers, non-governmental organizations (NGOs), and community leaders can also help spread awareness and promote sustainability more effectively at the community level (Idris, Ismail and Hashim, 2015).

2.5.3 Encouraging Sustainable Construction Research

Government and Universities encourage and advance sustainable construction research also a strategies for adopting sustainable construction (Hafez et al., 2023; Ma, 2023). Governments can influence the orientation of research in sustainable construction by their strategic funding and prioritisation of projects, which are specifically aimed at the attainment of innovative resolutions of existing environmental, economic, and social issues in the industry (Hafez *et al.*, 2023). The government can supply projects that concentrate on sustainable buildings with research grants, subsidies, or tax incentives (Ma, 2023). Such financing increases the interest of both academic institutions and other stakeholders of the industry in high-quality research activities. Governments may also create research national centres or support national research centres for sustainable construction (Hafez *et al.*, 2023). These institutes are in a position to focus on developing the next generation building technologies, increasing efficiencies in energy consumption, and developing new green building materials that have a lower carbon footprint and are less harmful to the environment.

Universities are hubs for innovation and knowledge creation. Not only can universities set up specific advanced research programs or departments focusing on sustainable construction, but they also create and conduct cutting-edge research which discovers how the building industry can be made more energy-efficient, which materials are free from both environmental pollution and toxic waste and how construction can be made smart and urban sustainability increased. Universities can do that by offering such programs as research grants and mentorship for students who research sustainable construction (Hafez *et al.*, 2023). Students may work on groundbreaking projects looking at new types of materials, technologies that are eco-friendly, or solutions for energy-efficient buildings. By doing so, universities create a new generation of professionals equipped to drive sustainability in the built environment.

2.5.4 Improve the Regulations and Policies of Sustainable Construction

According to Chan, Darko and Ameyaw (2017), improving the regulations and policies of sustainable construction in Malaysia is also a strategy. Although green certifications like the Green Building Index (GBI) are becoming more popular, the lack of mandatory rules still limits their use. Many developers continue to follow traditional construction methods because there are no strict laws that require sustainable practices. To solve this issue, the government should create clear and enforceable policies (Chan, Darko and Ameyaw, 2017). These rules should make it mandatory to use sustainable design, meet energy efficiency standards, and choose eco-friendly materials in both public and private projects. One important step is to include minimum green building standards in the national building codes (Chan, Darko and Ameyaw, 2017). These standards should also be part of the local authority approval process. This will help make sure that all new buildings support the country’s environmental goals. It is also important to align regulations across different government agencies. This can prevent conflicting rules and make project approvals faster and easier. In addition, the government should lead regular checks and audits to monitor sustainability performance. These efforts will help ensure that projects follow the rules and keep improving over time.

2.5.5 Provide Training for Construction Workers and Professional

Chan, Darko and Ameyaw (2017) determined that providing training for construction workers and professionals is a key strategy for promoting the adoption of sustainable construction in Malaysia. Training programs can equip workers with the technical know how to handle sustainable materials, manage construction waste, and utilize energy and water-efficient systems. For instance, site workers can be trained on how to minimize material waste to ensure proper segregation of recyclable waste by adopting safer, environmentally friendly construction methods.

At the same time, professional training for consultants, designers, and engineers should focus on important areas such as green building certification systems like the Green Building Index (GBI) and Leadership in Energy and Environmental Design (LEED) (CIDB, 2023). Training should also cover energy modelling, life-cycle cost analysis, and sustainable design methods. To keep construction professionals updated on the latest green technologies and rules, continuing professional development (CPD) courses, industry seminars, and workshops can be held. These programs can be organised in partnership with universities, green building councils, and agencies like the Construction Industry Development Board (CIDB) (CIDB, 2023).

2.5.6 Building Information Modelling

Waqar et al. (2023) and Manzoor et al. (2021) studied that Building Information Modelling (BIM) is also a strategy for sustainable construction. BIM is a digital process that helps the construction and architectural industries plan, design, build, and manage buildings and infrastructure more effectively(Waqar *et al.*, 2023). Rather than depending exclusively on traditional 2D drawings, BIM uses 3D models that contain not only visual data but precise information about every feature of the building.

One of the most significant advantages of BIM in sustainable construction is its ability to simulate and analyse energy performance during the design phase (Waqar et al., 2023; Manzoor et al., 2021). The designers and engineers can use 3D models to simulate the building's orientation for ventilation, lighting, and HVAC systems so they can predict energy consumption and select the optimal solutions (Waqar *et al.*, 2023). It enables such teams to determine the best layouts and materials for saving energy with a design phase that comes before actual construction starts. Building Information Modeling (BIM) also improves material efficiency. It allows for accurate quantity take-offs and detects clashes in the design before construction begins (Manzoor *et al.*, 2021). Such a process assists in the detection and avoidance of over-purchase, as well as correcting mistakes that can actually be expensive to the company's overall budget. Hence, this reduces material wastage and the environmental impact of the project is reduced. This contributes to a lower carbon footprint during the construction process. In the long run, Building Information Modeling (BIM) also supports facility management and maintenance (Manzoor *et al.*, 2021). It stores important data about building components, such as their lifespan, maintenance schedules, and energy use. This helps building owners manage operations more efficiently and keep everything running smoothly. By using this information, they can extend the building's lifespan and continue meeting sustainability goals over time. BIM can also support green building certification processes like GBI, LEED, or GreenRE (Manzoor *et al.*, 2021). It provides the required documents and performance data needed for these certifications. This makes the process easier and improves the chances of getting certified as a green building.

2.5.7 Improve Rating Tools and Certificate System for Malaysia's Sustainable Construction Inudstry

Ma (2023) discovered that improving rating tools and certificate systems can improve sustainable construction in Malaysia's construction industry. These tools set benchmarks to ensure the building meets the requirements. To accelerate the transition toward greener practices, there is a strong need to enhance the current rating frameworks and develop more robust certification systems that reflect Malaysia's unique environment. Malaysia's primary green building rating tool is the Green Building Index (GBI). It was launched in 2009 (Yusoff and Wen, 2014). Yusoff and Wen (2014) showed that it currently focuses on six categories which are energy efficiency, indoor environmental quality, sustainable site planning and management, materials and resources, water efficiency, and innovation. However, more emphasis on carbon footprint tracking, resilience to climate change, and life-cycle costing would make it more future-ready (Yusoff and Wen, 2014). GBI criteria should be further localised to consider Malaysia's climate, urban density, and resource availability. It is making it more practical and relevant for developers. Additionally, Green Building Index (GBI) can introduce sector-specific certification systems which have variations for homes, schools, retail, and data centers. For example, green infrastructure rating tools and certificates for roads, bridges, and public transport.

2.5.8 Enhancement of Green Building Codes

Ohueri, Enegbuma and Habil (2020) studied that establishing or enhancing green building codes is a strategy for adopting sustainable construction in Malaysia's construction industry. Many green initiatives remain voluntary, leading to limited adoption across the construction industry. By strengthening and updating green building regulations, authorities can set more comprehensive and enforceable sustainability standards for new developments and renovation projects (Ohueri, Enegbuma and Habil, 2020). This enhancement could involve making green certification mandatory for specific building types. For example, setting minimum requirements for energy efficiency, water conservation, indoor environmental quality, and eco-friendly materials. It may also require developers to integrate passive design features, renewable energy systems, and waste reduction strategies. Countries like Singapore have successfully used stricter green building codes, leading to better energy savings and stronger environmental protection (Chew, 2010). In the same way, Malaysia can improve its Green Building Index (GBI) framework and include it in national building regulations. This would encourage more people to follow sustainable practices. Stronger building codes would improve environmental performance and help developers meet international sustainability standards, making Malaysia more competitive globally (Ha, Khoo and Koo, 2023).

2.5.9 Modular Prefabrication

Using modular prefabrication is an effective strategy for adopting sustainable construction practices in Malaysia (Jaillon and Poon, 2008; Jiang et al., 2019). This method involves building components like walls, floors, or even whole rooms off-site in a controlled factory setting before they are transported to the construction site for assembly. Unlike traditional construction, where most of the work is done entirely on-site, often resulting in material wastage, delays, and higher energy consumption. Many research have examined the sustainable benefits of prefabrication. For example, Jiang et al. (2019) found the benefits of adopting prefabrication in raising the quality of prefabricated items, saving building time, reducing construction costs, and improving environmental performance and aesthetics.

Since modules are built in a controlled environment, materials will be precisely and efficiently used. Consequently, any waste will be kept at a minimum (Jaillon and Poon, 2008). The use of excess materials can also be easily recycled inside the factory instead of in an on-site condition. Modular prefabrication also shortens construction timelines because site preparation and module manufacturing can happen simultaneously (Jaillon and Poon, 2008; Jiang et al., 2019). Faster construction means reduced energy usage on-site, less machinery operation, and fewer emissions from transport and equipment. Moreover, factory-built components are usually of higher quality due to standardised manufacturing processes. Better construction quality translates to more energy-efficient buildings with improved insulation and airtightness (Jiang *et al.*, 2019). In Malaysia, using modular prefabrication can help solve labour shortages, improve productivity, and support green building goals under frameworks like the Green Building Index (GBI) and the Industrialised Building System (IBS) by CIDB. If modular construction is successfully used in public housing, schools, and healthcare facilities. It can set a good example and encourage more use of this method in the private sector.

2.5.10 Internet of Things (IoT)

The Internet of Things (IoT) can be an effective technique for implementing sustainable construction (Kineber, 2024; Singh et al., 2021; Chen et al., 2023). It refers to a network of physical devices, automobiles, appliances, sensors, and other items that are software, sensor, and internet-connected. These gadgets can gather, distribute, and process data via the internet. They can communicate with one another and with central systems, typically without human intervention (Singh *et al.*, 2021). It has the potential to improve operational intelligence and efficiency.

IoT-enabled solutions help improve trash management in buildings (Kineber, 2024). Smart bins can monitor garbage generation in real time. The data can be utilised to improve recycling and reduce landfill waste. The data can be used to improve recycling efforts and minimize landfill waste. In construction, IoT can monitor waste production during the building phase and help reduce material wastage by providing accurate data on how much material is being used and what needs to be ordered (Kineber, 2024; Singh et al., 2021). IoT can also optimise the supply chain for sustainable construction. Sensors in materials can track the location, condition, and usage of materials to minimise waste during the construction process (Kineber, 2024). IoT can enable the delivery of materials on time. This may lead to reduced storage requirements and ensure that the correct materials are used at the right time. Additionally, IoT safety sensors on machinery can detect the presence of workers or other equipment within a dangerous range (Kineber, 2024). The machineries are heavy duty machinery such as cranes, bulldozers and excavators. When a worker gets too close to a machine, the sensor alerts the operator or automatically stops the machine. It can prevent potential accidents.

2.5.11 Collaboration with Outsiders

Collaboration with external stakeholders, such as the private sector, research institutions, non-governmental organisations (NGOs), and international partners, is an effective strategy for adopting sustainable construction practices (Ma, 2023). Governments can also make collaboration possible between universities, research institutions, and the construction industry (Akreim and Suzer, 2018). For example, the government could finance joint research ventures, granting financial support and the ability to acquire industry expertise through public-private partnerships. These partnerships are beneficial in the sense that they foster the creation of particularly practical solutions suitable for expedient implementation in the field. The construction industry can cooperate with technology providers, green material suppliers, and energy management companies and work on integrating sustainable solutions into their projects (Ma, 2023). For instance, alliances with manufacturers of solar panels or wind energy companies would make it feasible to include renewable energy sources in buildings, thus reducing the dependence on established power systems.

2.5.12 Promoting Sustainable Construction in Private Sector

According to Chew (2010), strategies for adopting sustainable construction are promoting sustainable construction in the private sector. A significant reason for engaging private sector participation is by portraying sustainability as a competitive asset. The potential profits of developers from green construction consist of increased rental yields, higher occupancy rates, economic benefits in the long term, and enhanced brand reputation. In addition, the growing awareness among consumers regarding environmental issues means that tenants and buyers increasingly prefer buildings that are energy-efficient, healthier to live in and environmentally responsible (Chew, 2010). For example, during the construction of a commercial building called Tampines Concourse, the private sector in Singapore saved over 1000 tonnes of natural sand and granite. It offset 6750 tonnes of carbon dioxide (Chew, 2010). Public-private partnerships can also be leveraged to create pilot projects and innovative developments that showcase new sustainable technologies. By fostering collaboration between government, academia, and private companies, these partnerships can help test new ideas, share risks, and demonstrate the viability of green construction at different scales.

2.5.13 Market Creation for Sustainable Construction Materials

One significant barrier in Malaysia is the limited supply and competitiveness of eco-friendly building materials (Sin Tey *et al.*, 2015). Many developers resort to importing expensive green materials or compromising sustainability goals using conventional resources. To solve this issue, the industry needs to build a strong and supportive market for sustainable construction materials (Akindele *et al.*, 2023). It is important to encourage local manufacturers and suppliers to produce high-quality or certified green products like recycled aggregates, low-carbon concrete and sustainable timber. The government can support this by offering incentives and tax exemptions to companies that invest in these materials' research, development, and production (Sin Tey *et al.*, 2015). In addition, setting up reliable and transparent supply chains will reduce risks for developers working on green projects(Akindele *et al.*, 2023). Creating product directories, green material databases and proper certification systems will help confirm the quality and environmental performance of these materials.

2.5.14 Smart Building

Using IoT (Internet of Things) and smart sensors is an innovative and increasingly vital strategy for adopting sustainable construction in Malaysia (Zhuang *et al.*, 2020). Smart buildings integrate new technologies with building systems. Some of these are building automation, telecommunications, user life safety, and facility management systems. The smart building delivers actionable information that allows the building owner or tenants to operate the facility in an automated manner. In general, smart buildings use advanced technology to monitor and control internal activity. According to Zhuang et al. (2020), smart buildings have five main components, which are the HVAC system, software platform, networking and communication, sensor control devices and sensor actuators.

Smart buildings employ energy management systems that adjust lighting, temperature, and ventilation according to occupancy and usage patterns (Zhuang *et al.*, 2020). For example, smart lighting systems automatically turn off when rooms are not in use, while HVAC systems adjust based on indoor air quality and external weather conditions. This results in reduced energy consumption, lower utility bills, and a reduced carbon footprint (Zhuang *et al.*, 2020). Smart buildings also integrate water-saving technologies, such as smart irrigation systems and water metering (Zhuang *et al.*, 2020). These systems track water usage and adjust operations accordingly to prevent wastage. Water-efficient fixtures and rainwater harvesting systems can be monitored and optimised to reduce water consumption. All of these factors contribute to sustainability. After that, smart building systems help improve indoor air quality by automatically adjusting ventilation and air filtration to remove pollutants (Zhuang *et al.*, 2020). Sensors monitor air quality, humidity, and temperature to maintain the best conditions. This not only enhances the health and comfort of the occupants but also reduces the need for energy-heavy HVAC systems.

2.5.15 Integrated Project Delivery Method

The Integrated Project Delivery (IPD) method is a collaborative approach to construction that serves as a highly effective strategy for adopting sustainable construction practices (Chen, Liu and Yang, 2017). Chen, Liu and Yang (2017) stated that the IPD technique is a way of designing buildings that aim to meet tight financial and schedule limitations while performing well on a wide range of well-specified environmental and social objectives. Because of this, sustainable construction greatly depends on a multidisciplinary and cooperative team whose members make decisions based on a common vision and a comprehensive understanding of the project, which follows the design from pre-design to construction, occupancy, and operation (Chen, Liu and Yang, 2017).

One of the core principles of IPD is the early and active involvement of all professionals and clients during the design and planning stages (Chen, Liu and Yang, 2017). This makes it possible to include sustainability goals from the very beginning of the construction process. As a result, choices about green materials, energy-efficient systems, and environmental performance can be planned and made more effectively. IPD encourages the use of technologies such as Building Information Modeling (BIM), which helps visualise the project before construction begins (Chen, Liu and Yang, 2017). As mentioned above, BIM will reduce clashes and miscommunications, leading to less material waste, fewer change orders, and faster construction timelines. Sustainable construction needs close coordination between different fields. Integrated Project Delivery (IPD) supports a team-based approach where everyone works together toward common sustainability goals (Chen, Liu and Yang, 2017). This teamwork makes it easier to find smart solutions for sustainable design or sustainable systems that might be overlooked in the traditional method.

2.5.16 Loan With Low Interest Rate to Green Building

Malaysia's government should strengthen collaboration with banks to provide low-interest financing and implement fast-track approvals for sustainable projects. This is because sustainable construction has a high upfront cost in terms of materials and technologies. Generally, banks and traditional loan mechanisms have high interest rates that are not suitable for sustainable projects and discourage developers from this type of project. Banks should create preferential lines of loan for green projects with a 1-2% lower interest rate than the traditional loan. Government can make guarantees to lower the level of risks, like the Green Mark Incentive scheme of Singapore does (BCA, 2005). Similarly, authorities can consider providing a fast-track approval loan system for GBI or LEED-certified projects. Highly cut down on the bureaucratic process by creating work platforms that are digitally oriented and prioritise processing.

2.5.17 Demonstration Project and Case Studies

According to Akindele et al. (2023), demonstrate project and case studies of sustainable construction are also a strategy for adopting sustainable construction. Demonstration projects are real-world developments that showcase the successful application of sustainable construction principles, technologies, and practices. These projects serve as living examples that prove the practicality, benefits, and long-term value of green building initiatives to the construction industry (Femenías, 2004). Stakeholders can better observe how energy-efficient systems, passive design strategies, sustainable materials, and advanced construction techniques can be applied successfully in the local context by developing more pilot projects both in the public and private sectors. Iconic examples such as the Diamond Building in Putrajaya, Menara Kerja Raya, and Sime Darby Property's Elmina Central Park provide clear evidence of how green initiatives contribute to lower environmental impact (Jasspeed Singh *et al.*, 2021). Besides demonstration projects, creating detailed case studies is also very important (Akindele *et al.*, 2023). Case studies review completed green buildings by showing their design process, challenges, solutions, and results. They provide useful information for industry players and act as learning tools for future sustainable construction projects. By sharing data on energy savings, water efficiency, carbon reduction, and financial performance, these case studies can help answer common concerns about the feasibility and return on investment of sustainable construction (Femenías, 2004).

2.5.18 Environmental Impact Assessment

Implementing Environmental Impact Assessment (EIA) is a strategy for promoting sustainable construction in Malaysia's construction industry (Akindele et al., 2023; Joseph et al., 2020). An EIA is a systematic process used to evaluate the potential environmental consequences of a proposed construction project before any physical work begins (Joseph *et al.*, 2020). It ensures that possible adverse environmental impacts are identified and addressed at the planning and design stages, thereby promoting more responsible and sustainable development decisions. By integrating EIAs into every major construction project, developers and stakeholders can better understand how their projects might affect natural resources, ecosystems, biodiversity, air and water quality, and the surrounding communities. Projects can be redesigned or modified to reduce negative impacts through this early intervention (Joseph *et al.*, 2020). Moreover, conducting thorough EIAs encourages developers to adopt more sustainable techniques which are essential for reducing the overall environmental footprint of a project (Joseph *et al.*, 2020). It also facilitates better compliance with environmental regulations and international sustainability standards, strengthening the credibility and market value of the development.

2.5.19 Consolidation of the Role of Green Building Councils

Malaysia's primary organisation for advancing sustainable building techniques is the Malaysia Green Building Council (MalaysiaGBC) (Malaysia GBC, 2024). MalaysiaGBC actively supports green building initiatives, design methodologies, technology, and procedures (Malaysia GBC, 2024). It provides a forum for engaging diverse stakeholders in the adoption of sustainable practices that yield economic, social, and environmental advantages (Malaysia GBC, 2024).

Consolidation of the roles of Malaysia Green Building Councils is a strategy for adopting sustainable construction in Malaysia's construction industry (Akreim and Suzer, 2018; Chan, Darko and Ameyaw, 2017). Green Building Councils (GBCs) are essential to the creation and upkeep of standardised grading systems such as the Green Building Index (GBI) (Malaysia GBC, 2024). By consolidating their role, these councils can help harmonise sustainable building standards. They must ensure consistent implementation and recognition across the industry (Malaysia GBC, 2024). The GBI rates buildings according to standards such as indoor air quality, water conservation, energy efficiency, and the use of sustainable materials. As new practices and technologies are developed, GBCs can work with industry stakeholders and government organisations to update and enhance the rating systems in addition to establishing these standards. They can also strengthen their role by offering training programs for architects, engineers, contractors, and developers. These programs would improve the industry's ability to deliver sustainable projects and ensure that the workforce is capable of meeting green building standards. Furthermore, GBCs may develop certification programs for individuals, ensuring that professionals are prepared to work according to green building guidelines. By expanding their influence, Green Building Councils can effectively promote the widespread adoption of green building standards across both private and public sectors.

2.5.20 Establish More Green Building Associations

Establishing more green building associations is an effective strategy for encouraging the adoption of sustainable construction practices (Ohueri, Enegbuma and Habil, 2020). These associations can serve as important platforms to unite industry professionals and researchers in promoting environmentally responsible construction methods (Ohueri, Enegbuma and Habil, 2020). The construction industry can create more explicit guidelines and improve rating systems that suit local needs by establishing more organisations like the Malaysian Green Building Council (MGBC). Training, seminars, and certification programs also need to be provided to the public so that they can better understand sustainable construction. Furthermore, these associations can advocate for supportive policies, incentives and funding, as well as collaborate with international green building bodies to share best practices. The presence of multiple associations will accelerate the transition towards a more sustainable built environment in Malaysia.

Table 2.4: Literature Map for Strategies for Adopting Sustainable Construction in Malaysia's Construction Industry

Ref	Strategies	Akindele et al. (2023)	Akreim and Suzer (2018)	Chan, Darko and Ameyaw (2017)	Chen et al. (2023)	Chen, Liu and Yang (2017)	Chew (2010)	Darko et al. (2017)	Fathalizadeh et al. (2022)	Hafez et al. (2023)	Idris, Ismail and Hashim (2015)	Jiang et al. (2019)	Kineber (2024)	Ma (2023)	Manzoor et al. (2021)	Ohueri, Enegbuma and Habil (2020)	Omopariola et al. (2024)	Singh et al. (2021)	Timm, Maciel and Passuello (2023)	Waqar et al. (2023)	Zhuang et al. (2020)	Total
1	Increase Incentives for Sustainable Construction	✓	✓	✓			✓	✓	✓	✓	✓			✓		✓			✓			11
2	Increase the Awareness of Sustainable Construction for Public			✓			✓	✓	✓	✓	✓			✓	✓	✓	✓		✓			11
3	Encouraging Sustainable Construction Research	✓	✓	✓			✓	✓		✓	✓			✓		✓	✓					10
4	Improve the Regulations and Policies of Sustainable Construction	✓	✓	✓			✓	✓		✓				✓		✓						8
5	Provide Training for Construction Workers and Professional	✓	✓				✓		✓	✓				✓		✓	✓					8

Table 2.4: Literature Map for Strategies for Adopting Sustainable Construction in Malaysia’s Construction Industry

Ref	Strategies	Akindele et al. (2023)	Akreim and Suzer (2018)	Chan, Darko and Ameyaw (2017)	Chen et al. (2023)	Chen, Liu and Yang (2017)	Chew (2010)	Darko et al. (2017)	Fathalizadeh et al. (2022)	Hafez et al. (2023)	Idris, Ismail and Hashim (2015)	Jiang et al. (2019)	Kineber (2024)	Ma (2023)	Manzoor et al. (2021)	Ohueri, Enegbuma and Habil (2020)	Omopariola et al. (2024)	Singh et al. (2021)	Timm, Maciel and Passuello (2023)	Waqar et al. (2023)	Zhuang et al. (2020)	Total
6	Building Information Modelling (BIM)				✓	✓				✓			✓		✓	✓				✓		7
7	Improve Rating Tools and Certificate System	✓	✓	✓		✓				✓												5
8	Enhancement of Green Building Codes			✓			✓	✓		✓						✓						5
9	Modular Prefabrication					✓						✓					✓		✓			4
10	Internet of Things (IoT)				✓	✓							✓					✓				4

Table 2.4: Literature Map for Strategies for Adopting Sustainable Construction in Malaysia's Construction Industry

Ref	Strategies	Akindele et al. (2023)	Akreim and Suzer (2018)	Chan, Darko and Ameyaw (2017)	Chen et al. (2023)	Chen, Liu and Yang (2017)	Chew (2010)	Darko et al. (2017)	Fathalizadeh et al. (2022)	Hafez et al. (2023)	Idris, Ismail and Hashim (2015)	Jiang et al. (2019)	Kineber (2024)	Ma (2023)	Manzoor et al. (2021)	Ohueri, Enegbuma and Habil (2020)	Omopariola et al. (2024)	Singh et al. (2021)	Timm, Maciel and Passuello (2023)	Waqar et al. (2023)	Zhuang et al. (2020)	Total
11	Collaboration with Outsiders		✓							✓							✓					3
12	Promoting Sustainable Construction In Private Sector		✓				✓				✓											3
13	Market Creation for Sustainable Construction Materials	✓									✓								✓			3
14	Smart Building												✓								✓	2
15	Integrated Project Delivery Method				✓											✓						2

Table 2.4: Literature Map for Strategies for Adopting Sustainable Construction in Malaysia's Construction Industry

Ref	Strategies	Akindele et al. (2023)	Akreim and Suzer (2018)	Chan, Darko and Ameyaw (2017)	Chen et al. (2023)	Chen, Liu and Yang (2017)	Chew (2010)	Darko et al. (2017)	Fathalizadeh et al. (2022)	Hafez et al. (2023)	Idris, Ismail and Hashim (2015)	Jiang et al. (2019)	Kineber (2024)	Ma (2023)	Manzoor et al. (2021)	Ohueri, Enegbuma and Habil (2020)	Omopariola et al. (2024)	Singh et al. (2021)	Timm, Maciel and Passuello (2023)	Waqar et al. (2023)	Zhuang et al. (2020)	Total
16	Loan with Low Interest Rate to Green Building			✓				✓														2
17	Demonstration Project and Case Studies	✓								✓												2
18	Environmental Impact Assessment	✓														✓						2
19	Consolidation of the Role of Green Building Councils		✓																			1
20	Establish More Green Building Associations															✓						1

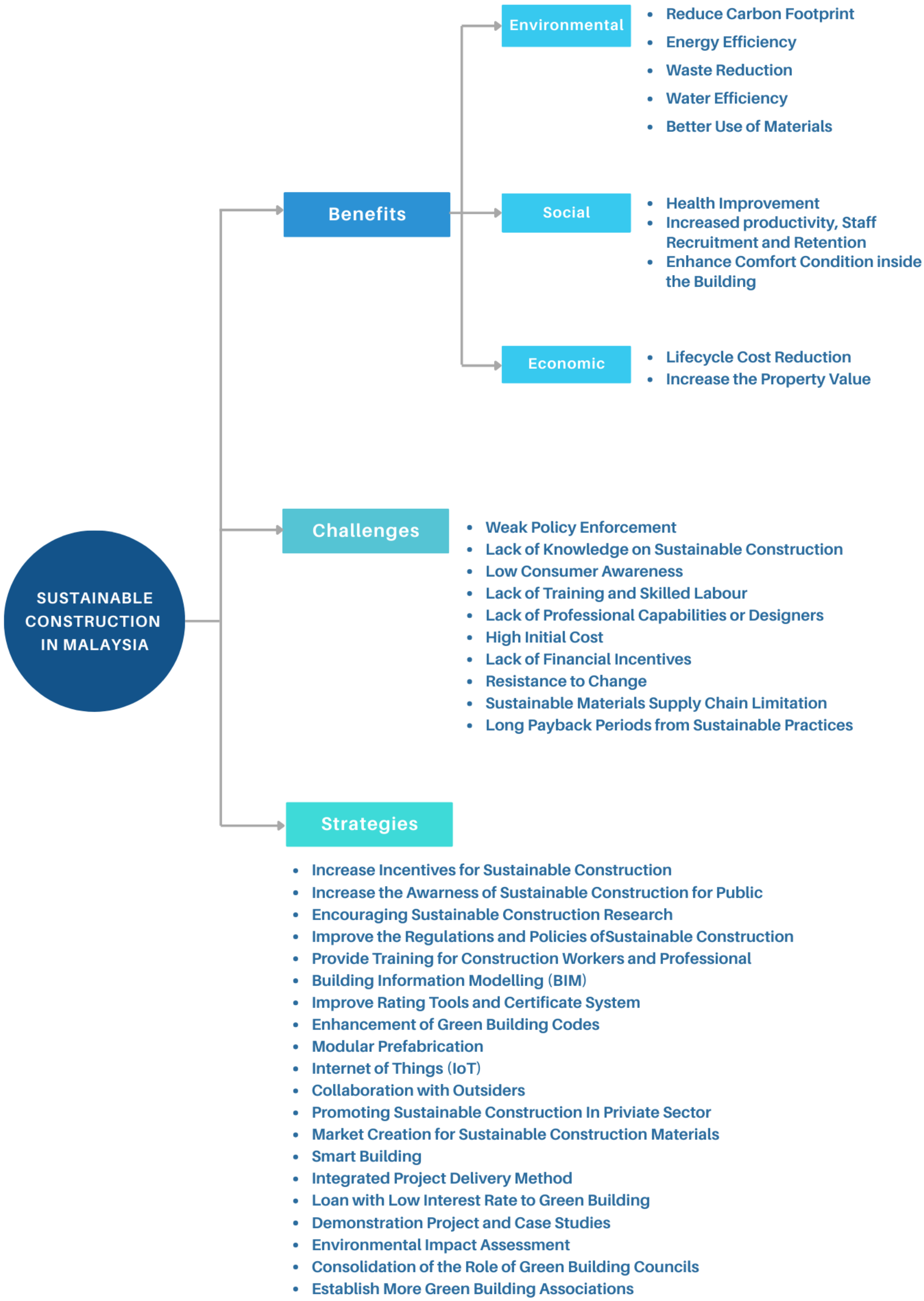

Figure 2.1: Framework of Benefits, Challenges and Strategies of Sustainable Construction In Malaysia's Construction Industry

2.6 Summary

To conclude, this chapter comprehensively explores the sustainable construction in Malaysia's construction industry. It covers the definition, advantages, barriers, and strategies related to sustainable construction in detail. Key insights from various research studies concerning the benefits, challenges, and strategic approaches for promoting sustainable practices were compiled and presented in Tables 2.2, 2.3 and 2.4. Based on a comprehensive review of earlier studies, the benefits of sustainable construction can be grouped into three categories: environmental, social and economic. Figure 2.1 presents the main elements of the benefits, challenges and recommended strategies for sustainable construction as identified by previous scholars. Gaining a clear understanding of these issues is crucial for developing effective solutions that will support wider implementation of sustainable practices, contributing to the long-term growth, environmental preservation, and social progress of Malaysia's construction industry.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

The research methodology used in this study will be the primary topic of Chapter 3. The study aims to uncover hidden patterns and insights using scientific techniques and analytical tools to interpret the collected data. Consequently, this chapter outlines the selected research methodology, which includes the research framework, sampling strategy, data collection methods, and data analysis procedures.

3.2 Research Methodology

According to Sreekumar (2025), research methodology is the methods and processes used to find and examine data related to a particular study topic. It is a procedure whereby researchers plan their studies and use the chosen research tools to accomplish their goals. By using the structure and guidelines provided by a research methodology, researchers can clearly describe their study questions, hypotheses, and objectives (Sreekumar, 2025).

There are two main types of data collection methods which are quantitative and qualitative. Quantitative methods involve collecting numerical data that can be measured and statistically analysed (Sreekumar, 2025). It often uses tools like surveys, questionnaires, and structured observations. On the other hand, qualitative methods focus on gathering descriptive data to gain deeper insights into opinions, behaviours, and experiences (Sreekumar, 2025). It typically uses interviews, focus groups and open-ended questions. In addition, the mixed-method approach can also be conducted in the study. It is an approach that combines both quantitative and qualitative techniques (Sreekumar, 2025).

In conclusion, selecting an appropriate research methodology and data collection method is essential for ensuring the reliability and relevance of a study's findings. By clearly defining the research framework and choosing between quantitative and qualitative approaches, researchers can effectively address their research objectives and gather meaningful data.

3.2.1 Selection of Quantitative Research

For this study, the quantitative research method will be chosen as the primary research method. The key reason for selecting quantitative research is its ability to collect data from a large number of respondents within a short period (Stevens, 2023). It is more highly efficient, time-effective and cost-efficient among all the methods (Stevens, 2023). This is especially important for studies involving the construction industry, where diverse perspectives from contractors, developers, consultants, and other stakeholders are necessary to understand sustainable construction practices in Malaysia comprehensively. Using tools such as structured questionnaires and surveys, quantitative research allows for the gathering of measurable and statistically reliable data. This data can then be analysed to identify trends and relationships related to the benefits, challenges, and strategies for adopting sustainable construction. The ability to reach many respondents quickly helps ensure that the findings are more representative of the industry.

3.3 Research Design

Saunders' Research Onion is a model introduced by Saunders et al. (2007) to guide researchers in structuring and designing their research methodology. It presents research design decisions in the form of layers of an onion. Each layer represents a step you need to consider while planning your research. The layers are philosophy, approach, strategies, choices, time horizon and technique and procedure (Crossley, 2021).

As shown in Figure 3.1, the pragmatism philosophy was adopted in this study. It allows the combination of objective and practical approaches to address real-world problems in the Malaysian construction industry. Then, a deductive approach was chosen to test existing theories related to sustainable construction against the data collected. The selected research strategy was a survey distributed through Google Forms to targeted respondents. It includes clients, consultants, and contractors within the Klang Valley region. The Klang Valley region was selected as the study area because it serves as Malaysia’s primary construction and development hub, where most advanced technologies, infrastructure, and innovative practices are concentrated. This makes it an ideal setting to investigate the adoption of sustainable construction strategies. For the methodological choice, this study employed a quantitative method, as it enables the collection of numerical data that can be statistically analysed and provides clear and objective results. After that, a cross-sectional design was applied in terms of time horizon. The data is collected at a single point to capture the current perspectives and practices related to sustainable construction. Finally, under the techniques and procedures layer, primary quantitative data was gathered through an online questionnaire. The collected data was then analysed using frequency analysis with the help of SPSS software.

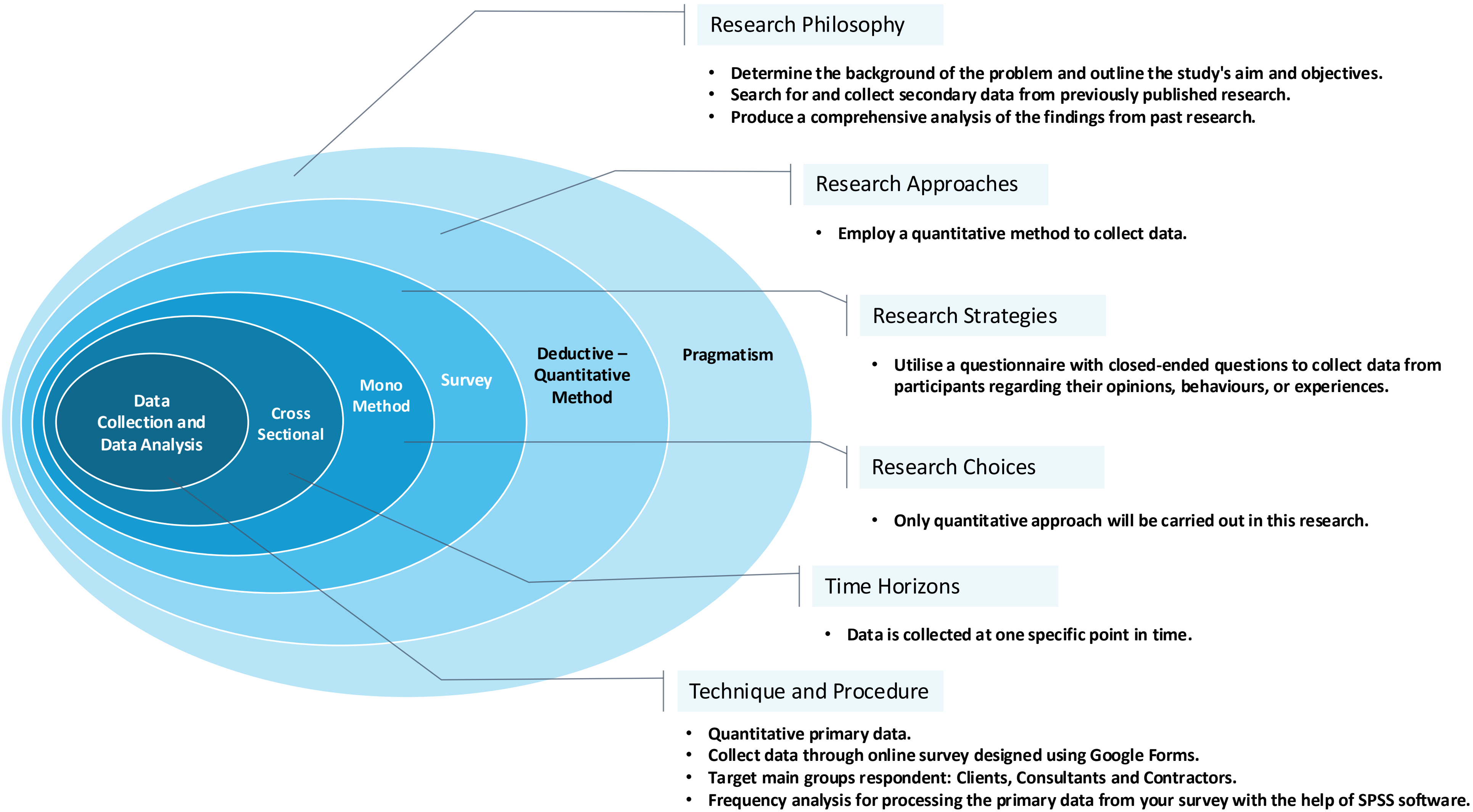

Figure 3.1: Research Flowchart (Saunders' Research Onion)

3.4 Sampling Design

Sampling design is the structured plan a researcher uses to select a subset of individuals from a larger group to participate in a research study (McCombes, 2023). Since this study is time-consuming to collect data from an entire population, the sampling design ensures that the selected sample accurately represents the whole population. It allows the researcher to make valid and reliable conclusions based on the sample data.

3.4.1 Sampling Method

There were two primary types of sample design, namely probability sampling and non-probability sampling (McCombes, 2023; Kabir, 2016). Probability sampling was a technique where every individual in the population had an equal chance of being selected (McCombes, 2023). This method included simple random sampling, stratified sampling, cluster sampling, and systematic sampling (McCombes, 2023). These approaches made the study highly representative and allowed the findings to be generalised to the entire population. However, they were often more time-consuming and required a complete list of the population, which was not always available. Non-probability sampling was a method where not all individuals had a known or equal chance of being selected (McCombes, 2023). The selection was often based on convenience or the researcher’s judgment. Examples included convenience sampling, purposive sampling, quota sampling, voluntary response sampling, and snowball sampling (McCombes, 2023). This quicker method carried a higher risk of bias and limited the generalisability of the results.

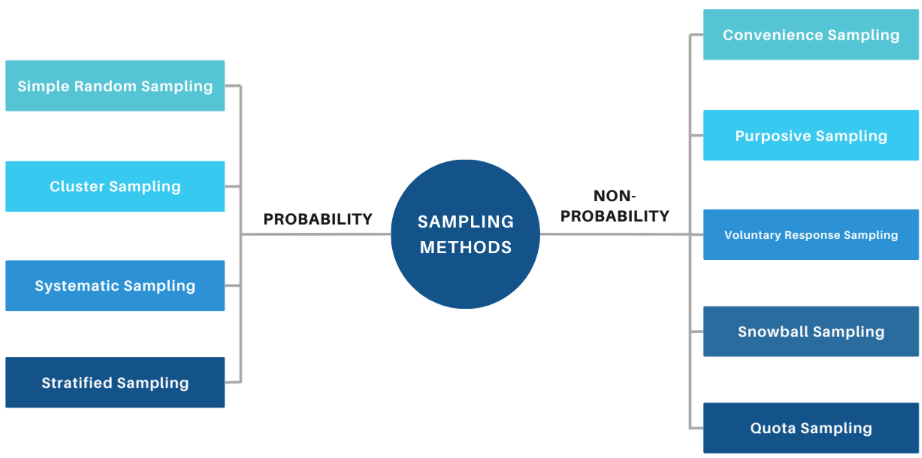

Figure 4.2: Types of Sampling Methods

Sources: McCombes, 2023

In this study, non-probability sampling methods were applied due to time constraints and the difficulty in accessing a complete list of the population within the Malaysian construction industry. According to Kabir (2016), non-probability sampling allowed the researcher to select respondents based on availability, relevance, and willingness to participate, making it practical and efficient for this research. Convenience sampling and snowball sampling were carried out in this study. Convenience sampling involved collecting data from respondents who were easily accessible and willing to participate (McCombes, 2023). It enabled the researcher to gather information quickly from construction professionals such as contractors, developers, and consultants. Snowball sampling expanded the respondent pool by relying on initial participants to refer other suitable respondents within their professional network (McCombes, 2023). This approach was particularly useful for reaching individuals involved in sustainable construction projects or those with relevant expertise who might not have been easily identifiable through conventional means.

3.4.2 Target Respondents

In this research, the target respondents are professionals directly involved in the Malaysian construction industry. This includes contractors, developers, and consultants with valuable insights and experience in sustainable construction practices. This study focuses on respondents located in the Klang Valley region. Klang Valley is the geographical focus because it represents Malaysia's most active and developed construction hub. Klang Valley also has a higher concentration of green building initiatives, infrastructure projects, and sustainable development efforts. According to the Department of Statistics Malaysia (2025), Selangor had the most extensive construction work done value of RM9.4 billion (22.5%) in the fourth quarter of 2024, followed by Wilayah Persekutuan with RM4.7 billion (11.3%). Professionals in this area are more likely to be exposed to and familiar with sustainable construction.

3.4.3 Sampling Size

Based on the rule of 5 per variable, a minimum sample size of 100 respondents is required for this study, considering the total of 20 variables assessed in strategies. According to the Central Limit Theorem, a minimum of 30 respondents per group ensures a normal data distribution within each category. The categories are client, consultant and contractor. Therefore, the targeted sample size involves at least 30 clients, 30 consultants, and 30 contractors, totalling 90 respondents. Moreover, the Raosoft sample size calculator was used to determine the appropriate sample size for this study. Based on the population size of construction professionals within the Klang Valley and considering a 95% confidence level with a 5% margin of error, the recommended sample size was 383 respondents (Kibuacha, 2022). According to Cook, Heath, and Thompson (2000), questionnaire-based studies commonly achieve less than 40% response rates. In line with this, 383 questionnaires were distributed to the targeted respondents, including contractors, developers, and consultants, through various online platforms such as email, WhatsApp, and professional networks. Considering the anticipated response rate of around 30%, the final number of valid responses received was 115. Therefore, the largest calculated sample size of 115 respondents will be adopted for this study, considering the three conditions for calculating the sample size.

3.5 Data Collection Method

3.5.1 Designation of Questionnaire

At the beginning of the survey, a succinct summary of the study was provided to give participants comprehended the research clearly. The three primary study objectives will be informed before proceeding with the survey. A self-administered questionnaire was developed, drawing upon findings from previous comprehensive research. It was carefully structured to convey the intended concepts to the respondents and aimed to achieve a satisfactory response rate. The survey comprised four parts that were intended to gather pertinent information in accordance with the research objectives.

Section A was designed to gather information regarding the respondents' personal and professional backgrounds. For example, academic qualifications, current designation, years of experience in the construction industry and type of organisation (contractor, consultant or developer). Section B focused on assessing the perceived benefits of sustainable construction within Malaysia's construction industry. This section contained 10 points to evaluate respondents' views on the potential benefits of adopting sustainable construction practices. The respondents were asked to rate the importance of each listed benefit based on their knowledge and professional experience. After that, Section C included 10 items that addressed the challenges and barriers hindering the implementation of sustainable construction in Malaysia. Respondents were required to express the degree to which they believed these challenges affected the successful adoption of sustainable practices. In addition, the final section, Section D, presented 20 variables that proposed various strategies to encourage the broader adoption of sustainable construction practices. To promote sustainable construction in Malaysia, respondents were asked to rank the significance of these tactics.

The five-point Likert Scale will be carried out in this questionnaire and utilised in Section B, Section C, and Section D. The Five-point Likert Scale has two extreme response options, two intermediate alternatives, and one neutral option (Sol, 2024). It provides survey respondents with a wide range of Likert scale possibilities to effectively represent their opinions (Sol, 2024). It is easy to use because users only need to choose how much they agree or disagree with a given statement.

Table 3.1: Five-point Likert Scale

Likert Scale Description	Likert-Scale
Strongly disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly agree	5

3.5.2 Pre-Test

The pre-test, also known as the Pilot test, is an initial assessment of the measures applied to a small subset of the population under investigation (Nelson, 2017). Before starting a more extensive study, pilot studies are utilised as feasibility studies to ensure the concepts or procedures underlying a research idea are sound and comprehend the study protocol (Nelson, 2017). This pre-test also includes gathering participant feedback about their understanding of the questions and overall experience completing the survey. The questionnaire was distributed to 2 developers, 2 consultants, and 2 contractors actively involved in the construction industry. It is to ensure the content is explicit and relevant. Based on their responses and suggestions, necessary improvements were made before distributing the final version to the entire sample group.

3.6 Data Analysis

After the final questionnaire was distributed to the targeted respondents and the required response rate was achieved, the collected data was carefully reviewed to handle any inconsistencies. The responses gathered were processed and analysed using Statistical Package for the Social Sciences (SPSS) software. SPSS is an easy-to-use software program for statistical data analysis and data-driven decision-making (Awati, 2024). This study applied six data analysis techniques, including Cronbach's alpha reliability test, Shapiro-Wilk Test, important score, Kruskal-Wallis test, Spearman's correlation test, and factor analysis. These methods were used to identify the key benefits, challenges, and adoption strategies related to sustainable construction practices.

3.6.1 Cronbach's Alpha Reliability Test

Cronbach's Alpha Reliability Test is a statistical tool used to measure the internal consistency or reliability of a set of survey or test items (Frost, 2024). In simpler terms, it checks how well a group of related questions measure the same underlying concept. In this study, the questions in Section B, Section C, and Section D of the questionnaire were evaluated using a five-point Likert scale. The Cronbach's Alpha reliability test was applied to assess the internal consistency and reliability of these Likert scale measurements. This test estimated the extent to which the items within each section consistently measured their intended concepts (Tavakol and Dennick, 2011). Eq 3.1 is the formula of Cronbach's Alpha Reliability Test (Frost, 2024).

$$\alpha = \frac{N\,(\mathrm{c})}{\mathrm{v}+(N-1)(\mathrm{c})} \tag{3.1}$$

where,
N = number of items
c = mean covariance between items
v = mean number variance

If the alpha value is around 1, the variables have a high level of internal consistency. On the other hand, low internal consistency is indicated by an alpha value near zero, which suggests that the variables are not highly associated and might not measure the same concept effectively. Table 3.2 states the ranging scale of Cronbach's alpha reliability.

Table 3.2: Ranging Scale of Cronbach's Alpha Reliability Coefficient

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

3.6.2 Shapiro-Wilk Test

Applying the Shapiro-Wilk test to a sample with the null hypothesis that it was drawn from a normal distribution is known as a hypothesis test (Malato, 2025). We can rule out such a null hypothesis and declare that the sample was not drawn from a normal distribution if the p-value is small (Malato, 2025). The Shapiro-Wilk test is especially recommended for small to medium-sized samples; typically, the sample size is less than 2000. It was chosen for this study because it is considered one of the most reliable and powerful methods for detecting deviations from normality, especially when dealing with small datasets or survey-based research. To verify the normality of the collected data, the Shapiro-Wilk test was performed using SPSS software. This test assessed whether the distribution of responses for each variable in the dataset significantly deviated from a normal distribution. If the significance value (p-value) was less than 0.05, the data was considered not normally distributed, justifying non-parametric statistical tests in subsequent analyses (Malato, 2025). However, the Shapiro-Wilk test has certain limitations. It can be highly sensitive in large samples, where even slight deviations from normality may appear significant, and it does not indicate the direction or type of non-normality present. Despite these limitations, it remains a widely accepted and appropriate test for assessing data normality in this research.

3.6.3 Mean Ranking

Mean ranking is a statistical technique used to determine the relative importance of each item based on respondents' ratings (Wan et al., 2014). In this study, mean scores were calculated from the five-point Likert scale responses provided in Sections B, C, and D of the questionnaire, which assessed the perceived benefits, challenges, and strategies related to sustainable construction practices in Malaysia's construction industry. Each item was assigned a mean value by averaging the responses collected. The items were then ranked from highest to lowest based on these mean values. The higher mean indicates greater perceived importance or relevance. The mean ($\bar{x}$) and standard deviation (σ) formula, as shown in Eq. 3.3 and Eq. 3.4 (Wan et al., 2014).

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{3.2}$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{(n-1)}} \tag{3.3}$$

where,

x_i = observed values of the sample (x_1, x_2, $x_3 \ldots$, x_n)

n = number of observations in the sample

3.6.4 Kruskal-Wallis Test

The Kruskal-Wallis Test is a type of non-parametric statistical test (Hecke, 2012). It is used to find out if there are meaningful differences between the medians of three or more independent groups (Hecke, 2012). This test is helpful when the data does not follow a normal distribution, meaning the data is not evenly spread or shaped like a bell curve. It is also commonly used when working with ordinal data. Ordinal data is information that can be ranked or ordered, but the gaps between values are not always equal. A good example of this is data collected using Likert scales, where respondents might choose options like “strongly agree,” “agree,” or “disagree.” Since this data type is ranked but not measured precisely, the Kruskal-Wallis Test is suitable. This test was selected for the present study because it does not assume normality and is effective for analysing ordinal or non-normally distributed data obtained from surveys. It also allows comparison across multiple independent groups without requiring equal sample sizes or variances.

In this study, the Kruskal-Wallis Test was applied to compare the perceptions of three different respondent groups, clients, consultants, and contractors, towards the benefits, challenges, and strategies of sustainable construction in Malaysia. The study aimed to identify whether significant differences exist between these groups’ views on sustainable construction practices. If the test result shows a p-value equal to or less than 0.05, it indicates that at least one group differs significantly from the others in response patterns. However, the Kruskal–Wallis Test has certain limitations. While it can determine that a difference exists, it does not specify which specific groups differ significantly from each other; post-hoc tests are required for that. In addition, it may have reduced statistical power compared to parametric alternatives when the data are approximately normal. Despite these limitations, the Kruskal–Wallis Test remains a robust and appropriate method for analysing group differences in this research. The formula of the Kruskal-Wallis Test is as below (Hecke, 2012):

$$H = \left[\frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i}\right] - 3\,(N+1) \tag{3.4}$$

where,

N = total size of the sample

k = number of groups used for comparison

n_i = the sample size in the ith sample

R_i = the sum of the ranks related to ith group

3.6.5 Spearman's Correlation Test

The Spearman's Correlation Test is a non-parametric statistical method used to measure the strength and direction of the association between two ranked variables (Rebekić et al., 2015). It is based on the ranked values of the data rather than the raw data itself. It makes it suitable for both ordinal data and continuous data that do not meet the assumptions of normality. This test evaluates whether the relationship between the variables is monotonic. As one variable increases, the other tends to either increase or decrease consistently. The correlation coefficient is denoted by Spearman's rho (ρ), ranging from +1 indicating a perfect positive correlation, 0 indicating no correlation, and -1 indicating a perfect negative correlation (Rebekić et al., 2015). When the p-value is below 0.05, it suggests that the results are unlikely to have occurred by chance alone. In other words, enough evidence supports the idea that a true relationship exists between the variables being studied. If the p-value is higher than 0.05, it usually means the results are insignificant, and any difference or relationship seen might be due to random variation (Rebekić et al., 2015). The Spearman's Correlation Test is calculated by using the formula (Guo, 2022):

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{3.5}$$

where,

ρ = Spearman's rank correlation coefficient

d_i = difference between the two ranks of each observation

n = number of observations

3.6.6 Factor Analysis

According to Williams, Onsman, and Brown (2010), Factor Analysis is a statistical method used to identify patterns or groups within a large set of data.

It helps researchers uncover hidden relationships between many variables by grouping them into smaller, related categories called factors. Secondly, Factor Analysis reveals connections between measured variables and unseen concepts (Williams, Onsman and Brown, 2010). This allows researchers to form and improve theories by showing how different variables are linked. Factor Analysis also provides evidence for construct validity, helping to confirm whether a self-reporting scale accurately measures what it is intended to measure (Williams, Onsman and Brown, 2010). In this study, Factor Analysis was employed to categorise various strategies for sustainable construction adoption into distinct groups, enabling a clearer understanding of the underlying dimensions and providing a structured basis for analysing stakeholder perceptions.

There are two major types of factor analysis which are Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Williams, Onsman and Brown, 2010). EFA is broadly exploratory and heuristic (Watkins, 2018). In EFA, the researcher has no specific expectations about the number or nature of the underlying variables (Hox, 2021). As the name suggests, it is used to explore the main dimensions within a large set of latent constructs, often represented by a group of items. This process helps researchers identify patterns and develop theories or models based on the data. In contrast, CFA is used to test a proposed theory or model. It is a type of structural equation modelling where the researcher begins with clear assumptions and expectations drawn from existing theory (Watkins, 2018). CFA evaluates whether the data fits a predetermined structure, confirming the number of factors and how the variables relate to those factors. While EFA helps generate theories, CFA helps test and validate them.

Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity are two important tests used in factor analysis to check whether the data suits this type of analysis (Williams, Onsman and Brown, 2010). The KMO Test measures how well the variables in a dataset are related and whether they are likely to be grouped into factors. The KMO value ranges from 0 to 1. A value closer to 1 means the data is suitable for factor analysis. Generally, a KMO value of 0.6 or above is acceptable, while values above 0.8 are excellent. Williams, Onsman and Brown (2010) also stated that Bartlett's Test of Sphericity checks whether there are significant relationships between the variables in the dataset. It tests the null hypothesis that the variables are unrelated and unsuitable for factor analysis. If the p-value is less than 0.05, it means the test is significant, and factor analysis can be used.

3.6.7 Summary

This chapter presents a systematic overview of the research methodology applied in this study, which investigates sustainable construction practices in Malaysia. The research adopts a quantitative approach by using structured questionnaires to gather numerical data that can be analysed statistically. Convenience sampling and snowball sampling techniques were employed to select participants. Convenience sampling involves approaching readily available respondents, while snowball sampling relies on initial participants to refer additional respondents within their networks. This combination was chosen to access industry professionals, developers, consultants, and contractors actively involved in construction projects. The target was to collect at least 115 valid responses within the Klang Valley area. For data analysis, the six techniques will be identified, including Cronbach's alpha reliability test, Shapiro-Wilk test, mean ranking, Kruskal-Wallis test, Spearman's correlation test and factor analysis. In conclusion, this chapter outlines a structured and practical research design, ensuring reliable and relevant data collection for evaluating sustainable construction practices in Malaysia.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results of the questionnaire survey on sustainable construction. The findings are examined in relation to the research objectives, with the aim of enhancing the understanding of the benefits, challenges, and strategies associated with sustainable practices in the construction industry. The collected survey data were analysed using the Statistical Package for the Social Sciences (SPSS), and the results are presented through five different statistical tests. Tables and figures are included to illustrate key patterns, while the discussion interprets the outcomes by comparing them with previous studies and relevant literature.

4.2 Outcome of Pre-Test

Prior to the main data collection, a pre-test of the questionnaire was conducted to ensure clarity, consistency, and reliability of the instrument. Pre-testing is an important step in survey research as it allows the researcher to identify and resolve potential issues in wording, question sequence, or administration mode before proceeding to the main study (DuBay and Watson, 2019). In this research, a total of six respondents participated in the pre-test, comprising two contractors, two consultants, and two developers, thereby representing the primary categories of stakeholders targeted in the study. The response rate was 100%, and the feedback indicated that the questionnaire was clear, relevant, and easy to understand. No problems were reported regarding ambiguity or difficulty in answering the questions. As no issues were identified, no modifications were required. Therefore, the instrument was deemed valid and suitable for use in the main survey.

4.3 Questionnaire Response Rate

A total of 329 questionnaires were distributed to employed respondents across Malaysia through two main channels, namely email invitations and social media platforms such as Instagram, WhatsApp, and Redbook. These channels were selected to maximize outreach and ensure that respondents from various backgrounds and sectors had equal opportunities to participate in the survey. Over a period of five weeks, a total of 120 valid responses were collected after screening for completeness and relevance. This represents a response rate of approximately 36.5%, which is generally considered acceptable for survey-based research (Memon et al., 2020). The response rate reflects a reasonable level of engagement from the target respondents, indicating that the chosen distribution methods were effective in reaching a diverse pool of participants and providing a sufficient and reliable sample size for analysis (Memon et al., 2020).

4.4 Profile of Respondents

The demographic profile of the respondents shows a diverse representation across different categories. In terms of the nature of organisation, 47.5% of respondents were from contractors, followed by 27.5% from consultants and 25% from developers. For education level, the majority (83.3%) held a degree, while 10% had a diploma and 6.7% possessed postgraduate qualifications, with no respondents from high school level. Regarding working experience, most respondents had between 5-10 years (46.7%) and less than 5 years (35.8%), while smaller proportions reported 11-15 years (12.5%) and 16-20 years (5.0%), with none having more than 20 years of experience. In terms of position in the company, executives comprise the largest group (72.5%), followed by managers (19.2%), senior managers (6.7%), and top management/directors (1.7%). This distribution indicates that the survey captured perspectives from a wide range of professionals, with strong representation from contractors, degree holders, and executives.

Table 4.1: Demographic Profile of Respondents

Parameter	Categories	Frequency	Percentage (%)
Nature of Organisation	Developer	30	25.0
	Consultant	33	27.5
	Contractor	57	47.5
Education Level	High School	0	0.0
	Diploma	12	10.0
	Degree	100	83.3
	Postgraduate	8	6.7
Working Experience	Less than 5 years	43	35.8
	5 – 10 years	56	46.7
	11 – 15 years	15	12.5
	16 – 20 years	6	5.0
	> 20 years	0	0.0
Position in Company	Executive	87	72.5
	Manager	23	19.2
	Senior Manager	8	6.7
	Top Management / Director	2	1.7

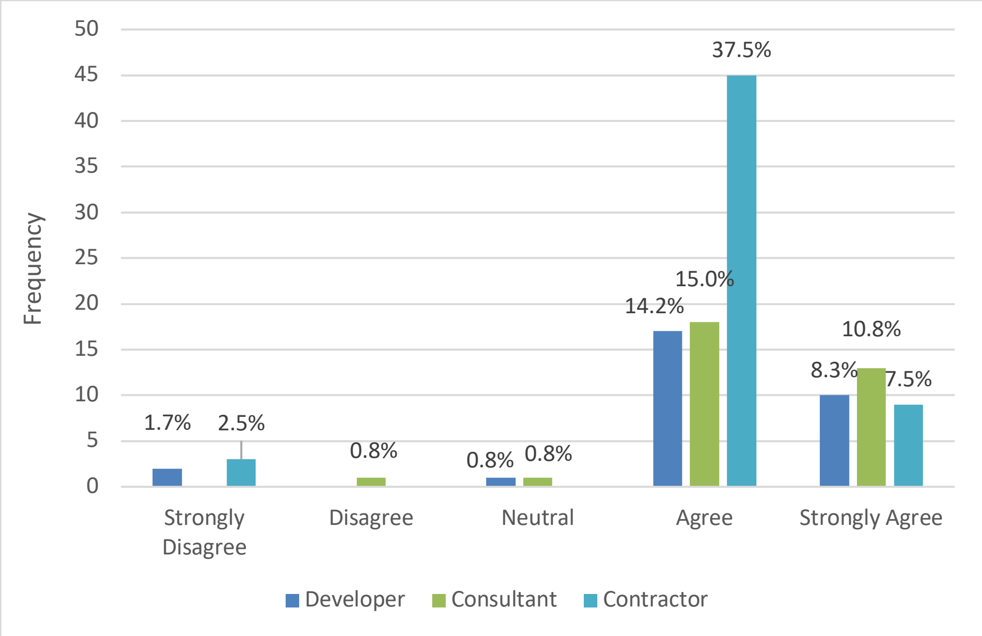

Figure 4.1: Sustainable construction practices positively impact environmental, economic, and social aspects

Figure 4.1 presents the level of agreement among developers, consultants, and contractors regarding the positive impacts of sustainable construction practices. The findings show that the majority of respondents across all groups either agreed or strongly agreed with the statement. Among contractors, 37.5% agreed while 7.5% strongly agreed, indicating a strong recognition of the sustainability benefits. Consultants also demonstrated high support, with 15.0% agreeing and 10.8% strongly agreeing. Similarly, developers reflected positive perceptions, with 14.2% agreeing and 8.3% strongly agreeing. Only a very small percentage of respondents selected neutral or disagreement options, while strong disagreement was minimal among developers (1.7%) and contractors (2.5%). Overall, the results underscore a clear consensus that sustainable construction practices are widely recognised to offer environmental, economic, and social benefits in the construction industry.

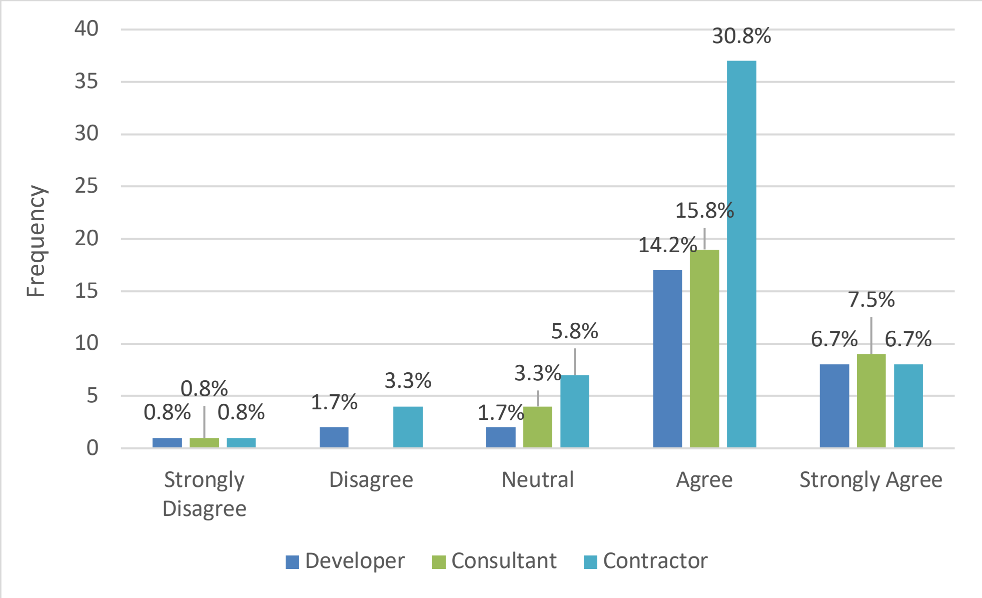

Figure 4.2: Barriers in sustainable construction discourage public support for green building initiatives in Malaysia

Figure 4.2 illustrates the level of agreement among developers, consultants, and contractors on whether barriers in sustainable construction discourage public support for green building initiatives. The majority of respondents across all three groups expressed agreement. Among contractors, 30.8% agreed and 6.7% strongly agreed, making them the group with the strongest consensus. Consultants also showed similar support, with 15.8% agreeing and 7.5% strongly agreeing, while developers reported 14.2% agreeing and 6.7% strongly agreeing. Neutral responses were relatively low, with contractors at 5.8%, consultants at 3.3%, and developers at 1.7%. Disagreement was minimal, with only small percentages of developers (1.7%) and contractors (3.3%) disagreeing. Overall, the results suggest that most industry professionals believe that unresolved barriers to sustainable construction can significantly undermine public confidence and support for green building initiatives in Malaysia.

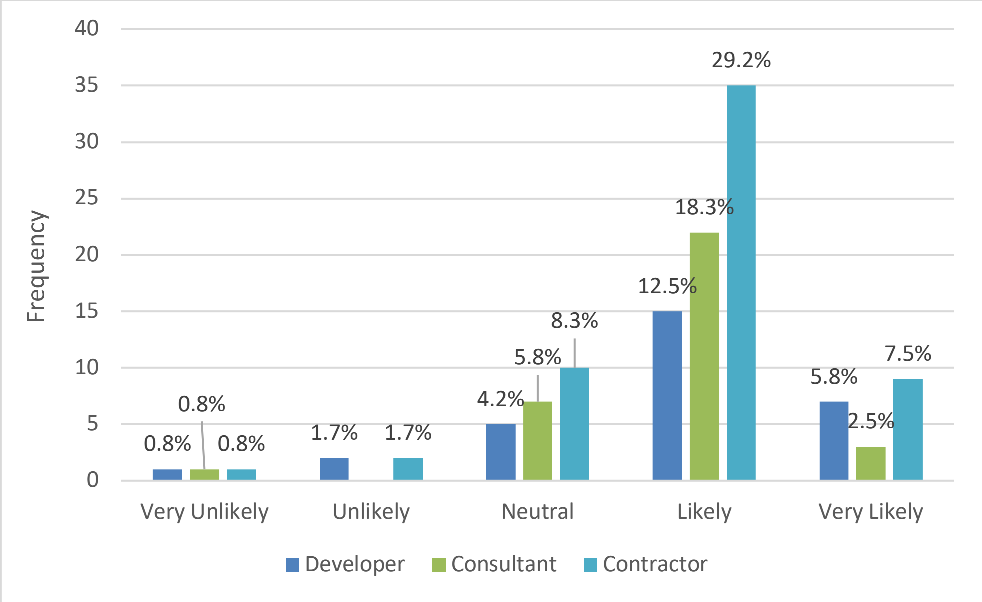

Figure 4.3: The Malaysian construction industry is likely to adopt sustainable construction practices on a wide scale in the near future.

Figure 4.3 shows respondents' views on the likelihood of the Malaysian construction industry adopting sustainable construction practices on a wide scale in the near future. Overall, the majority expressed optimism, with 29.2% of contractors, 18.3% of consultants, and 12.5% of developers indicating the industry is "likely" to adopt such practices. A smaller proportion considered it "very likely," with 7.5% of contractors, 2.5% of consultants, and 5.8% of developers. Neutral responses accounted for 8.3% of contractors, 5.8% of consultants, and 4.2% of developers. Only a very small percentage selected "unlikely" or "very unlikely," with less than 2% across all groups. These results highlight a generally positive outlook among industry professionals, particularly contractors, regarding the future adoption of sustainable construction in Malaysia.

4.5 Cronbach's Alpha Reliability Test

Cronbach's alpha is a widely used measure of internal consistency or reliability for questionnaire items. According to Tavakol and Dennick (2011), acceptable values of Cronbach's alpha generally range from 0.70 to 0.95, where values closer to 1.0 suggest higher internal consistency. In Table 4.2, the results show that all three categories achieved acceptable levels of internal consistency, with Cronbach's alpha values above 0.7. Specifically, the Benefits of Sustainable Construction (α = 0.800) and Challenges of Sustainable Construction (α = 0.794) categories demonstrate good reliability, while the Strategies for Adopting Sustainable Construction category recorded the highest value (α = 0.891), reflecting excellent internal consistency. These results confirm that the questionnaire items are reliable and suitable for further statistical analysis.

Table 4.2: Cronbach's Alpha Reliability Test Result

Category	**Number of Items**	**Cronbach's alpha**
Benefit of Sustainable Construction	10	0.800
Challenges of Sustainable Construction	10	0.794
Strategies for Adopting Sustainable Construction	20	0.891

4.6 Normality Test – Shapiro-Wilk Test

In this study, the normality of the data was assessed using the Shapiro-Wilk test, which is widely recommended for small to medium sample sizes due to its higher power in detecting deviations from normality compared to other tests (Frost, 2024). The null hypothesis (H_0) for the Shapiro-Wilk test states that the data is normally distributed. The SPSS analysis yielded p-values of less than 0.001 for all three categories. Since these values are below the significance level of 0.05, the null hypothesis was rejected. This indicates that the data do not follow a normal distribution; therefore, non-parametric statistical methods such as Kruskal-Wallis test and Spearman correlation test were considered more appropriate for further analysis.

Table 4.3: Test of Normality for Benefit of Sustainable Construction

Ref	Benefit of Sustainable Construction	Shapiro-Wilk
		Sig.
B1	Reduce Carbon Footprint	<0.001
B2	Energy Efficiency	<0.001
B3	Waste Reduction	<0.001
B4	Water Efficiency	<0.001
B5	Better Use of Materials	<0.001
B6	Health Improvement	<0.001
B7	Increased productivity, Staff Recruitment and Retention	<0.001
B8	Enhance Comfort Condition inside the Building	<0.001
B9	Lifecycle Cost Reduction	<0.001
B10	Increase the Property Value	<0.001

Table 4.4: Test of Normality for Challenges of Sustainable Construction

Ref	Challenges of Sustainable Construction	Shapiro-Wilk
		Sig.
C1	Weak Policy Enforcement	<0.001
C2	Lack of Knowledge on Sustainable Construction	<0.001
C3	Low Consumer Awareness	<0.001
C4	Lack of Training and Skilled Labour	<0.001
C5	Lack of Professional Capabilities or Designers	<0.001
C6	High Initial Cost	<0.001
C7	Lack of Financial Incentives	<0.001
C8	Resistance to Change	<0.001
C9	Sustainable Materials Supply Chain Limitation	<0.001
C10	Long Payback Periods from Sustainable Practices	<0.001

Table 4.5: Test of Normality for Strategies for Adopting Sustainable Construction

Ref	Strategies for Adopting Sustainable Construction	Shapiro-Wilk
		Sig.
S1	Increase Incentives for Sustainable Construction	<0.001
S2	Increase the Awareness of Sustainable Construction for Public	<0.001
S3	Encouraging Sustainable Construction Research	<0.001
S4	Improve the Regulations and Policies of Sustainable Construction	<0.001
S5	Provide Training for Construction Workers and Professional	<0.001
S6	Building Information Modelling (BIM)	<0.001
S7	Improve Rating Tools and Certificate System	<0.001
S8	Enhancement of Green Building Codes	<0.001
S9	Modular Prefabrication	<0.001
S10	Internet of Things (IoT)	<0.001
S11	Collaboration with Outsiders	<0.001
S12	Promoting Sustainable Construction In Private Sector	<0.001
S13	Market Creation for Sustainable Construction Materials	<0.001
S14	Smart Building	<0.001
S15	Integrated Project Delivery Method	<0.001
S16	Loan with Low Interest Rate to Green Building	<0.001
S17	Demonstration Project and Case Studies	<0.001
S18	Environmental Impact Assessment	<0.001
S19	Consolidation of the Role of Green Building Councils	<0.001
S20	Establish More Green Building Associations	<0.001

4.7 Benefits of Sustainable Construction in Malaysia's construction industry

4.7.1 Mean Ranking

Table 4.6 presents the mean and standard deviations of the benefits of sustainable construction in Malaysia's construction industry. Respondents were asked to indicate their level of agreement on the occurrence of these benefits in the construction industry, using a five-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree". Overall, most variables achieved a mean score exceeding 3.50, indicating a level of agreement slightly higher than the neutral mid-point of 3.00. Since the mean score is higher than 3.0, which represents the neutral point on the scale, it indicates that the participants' responses are generally positive. This shows that respondents generally agreed with the statements. Therefore, the results can be considered satisfactory and meaningful for the purposes of this study. The benefits of sustainable construction in Malaysia's construction industry are ranked in accordance with the mean and standard deviation computed as shown in Table 4.6, the top five benefits of sustainable construction are:

(i) Health Improvement (Mean = 4.34, δ = 0.628)
(ii) Reduce Carbon Footprint (Mean = 4.25, δ = 0.748)
(iii) Waste Reduction (Mean = 4.20, δ = 0.729)
(iv) Water Efficiency (Mean = 4.20, δ = 0.559)
(v) Lifecycle Cost Reduction (Mean = 4.19, δ = 0.781)

Health improvement is ranked as the most significant benefit of sustainable construction in the Malaysian construction industry in this study. A previous study by Ahiabu, Emuze, and Das (2023) also highlighted that sustainable construction enhances the health, comfort, and overall well-being of the population, which remains a key priority in many developing countries. The findings of this study are therefore consistent with their results. Hoxha and Shala (2019) also found that respondents predominantly believe sustainable construction delivers tangible social benefits, including enhanced indoor comfort, improved well-being and health, reduced stress and fatigue, and better emotional functioning. In addition, sustainable construction promotes healthier and safer built environments by creating non-toxic indoor spaces (Ejiofor et al., 2018). It also improves occupational health and safety during construction, and enhances the overall quality of life for building occupants and surrounding communities.

Reducing carbon footprint ranked second in the ranking. Bhattarai et al. (2025) stated that the building and construction industry is a major contributor to global greenhouse gas (GHG) emissions, accounting for around 37% of global emissions and significant energy demand. A high reliance on energy-intensive materials such as cement, steel, and aluminium intensifies its carbon footprint (Ranjetha et al., 2022). It reflects that the respondents are increasingly aware of the environmental impacts of conventional construction practices and recognize the importance of adopting sustainable approaches. Uddin et al. (2025) mentioned that sustainable construction can reduce carbon emissions by utilising recyclable, reusable, and biodegradable materials, which significantly lowers the carbon footprint of buildings and promotes sustainable development. Advances in material science, particularly the development of innovative materials and technologies, continue to drive progress in sustainable construction. Ultimately, reducing the carbon footprint contributes to protecting the environment and supporting long-term ecological balance.

After that, waste reduction is ranked as the third most significant benefit of sustainable construction. Papargyropoulou et al. (2011) highlighted that the negative environmental effects of the construction sector are also associated with the development of construction waste and the unsustainable use of finite natural resources as building materials. Construction waste constitutes one of the largest waste streams in Malaysia; however, despite several government initiatives aimed at addressing this issue, the implementation of sustainable resource and waste management practices on construction sites remains limited among contractors (Begum, 2009). According to Ismam and Ismail (2014), the strategic implementation of construction waste management should be initiated by the government as the main driver in formulating effective plans. The conceptual framework highlights four key measures which are regulation, policy, technology, and guidelines. It is to ensure efficient adoption of the 3R strategy (reduce, reuse, recycle). Comparative analysis shows that while the 3R principles form the foundation, developed countries have expanded the framework to include "disposal" due to the unavoidable waste generated (Nagapan et al., 2012). Hence, the focus should be on minimising landfill disposal by increasing the reuse and recycling of construction materials.

Therefore, water efficiency was identified as the fourth most significant benefit among the ten examined in this study. Respondents recognised its importance as it helps minimise freshwater consumption, reduce operational costs and ensure long-term resource availability. Within the context of sustainable construction, water efficiency is also linked to broader environmental conservation efforts, as it reduces pressure on local water supplies and decreases the generation of wastewater (Al-Qawasmi et al., 2019). This indicates that industry stakeholders are increasingly aware that efficient water management is not only an environmental necessity but also an economic advantage that supports the overall sustainability of construction projects (Khoo et al., 2024). Flores and Ghisi (2022) mentioned that sustainable water strategies such as rainwater harvesting, greywater reuse, and low-flow technologies can cut building water use by up to 50 %, while also bolstering resilience to water scarcity. Major certification frameworks, including LEED, BREEAM, and Malaysia's own GBI, further underscore water efficiency's strategic role by offering rating incentives for adopting water-saving practices (Belahoucine, 2024).

Lastly, "Lifecycle Cost Reduction" was ranked as the fifth most significant benefit among the ten examined in this study. This indicates that respondents value the long-term economic savings achieved through sustainable construction practices, which lower operational, maintenance, and replacement costs over a building's lifespan. Haugbolle and Raffnsoe (2019) demonstrate that even modest upfront investments in sustainability, typically around 2% higher construction costs, can yield lifecycle savings exceeding ten times that amount over the building's life. In some cases, the returns on green construction investments can be 20 times greater than the initial outlay

(Haugbolle and Raffnsoe, 2019). A study in Indonesia similarly demonstrated that although green buildings cost 10–20% more upfront (Sutikno et al., 2025). Sutikno et al. (2025) reap operational and maintenance cost reductions of 15 to 30%, resulting in payback periods of under four years.

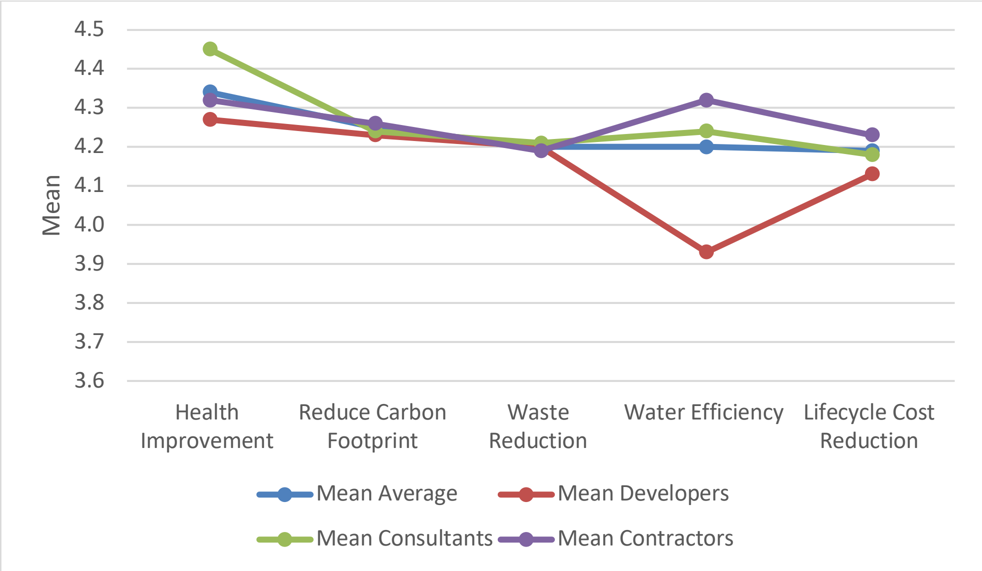

Figure 4.4: Profiles of Benefits for Mean Ranking Across Stakeholders

This graph illustrates the profiles of benefits for mean ranking across different stakeholders. Thay are developers, consultants, contractors, and the overall average. It compares how each group rated the top five key benefits. The results indicate that health improvement received the highest overall rating, with consultants placing particular emphasis on this criterion. Conversely, water efficiency exhibited the greatest divergence in stakeholder perception, as contractors rated it relatively highly, while developers assigned it the lowest score among all categories.

4.7.2 Comparison with Previous Studies

In order to consolidate the research findings, a comparison between the results of this study and studies from other nations was carried out. Previous research from a few emerging nations, including Greece, Canada, Sri Lanka, Ghana, Nigeria, United Kingdom and Malaysia, is compiled in Table 4.7. According to a comparison with earlier research, other developing countries similarly acknowledge the top five advantages of sustainable building practices in Malaysia. Notably, eight prior studies conducted in nations such as Greece, Canada, Sri Lanka, Ghana, Nigeria, and the United Kingdom highlighted waste reduction and health improvement as two of the five most significant benefits of sustainable construction. Although the present study focuses on Malaysia, the comparative analysis in Table 4.7 demonstrates that the identified advantages are consistent with those reported in other developing nations, suggesting that the benefits of sustainable construction are broadly applicable across different contexts. This cross-country consistency reinforces the validity of the findings and indicates that sustainable construction practices can yield similar environmental, economic, and social benefits in emerging economies worldwide.

4.7.3 Kruskal-Wallis Test

The Kruskal-Wallis Test was conducted to test whether there is a significant difference in the ranking of those 10 benefits of sustainable construction among contractors, consultants and developers. Table 4.6 shows that there is no significant difference for all of the benefits of sustainable construction except water efficiency. The water efficiency test result revealed a statistically significant variation in the three groups' rankings. In particular, water efficiency was consistently ranked as one of the top three benefits by both consultants and contractors, but developers gave it a much lower ranking, ranking it seventh. This discrepancy implies that developers might not view water efficiency as a top advantage, in contrast to consultants and contractors who do.

Water efficiency is directly related to operational performance, long-term cost savings, and environmental compliance. While, consultants and contractors are heavily involved in project design and implementation. As a construction professional, they are more knowledgeable about the environmental and technical significance of water efficiency. Especially in reducing resource scarcity and guaranteeing sustainable building performance. On the other hand, developers are mainly focused on a project's overall profitability and initial cost implications. Water efficiency is often given less priority by developers because its financial benefits might not be as obvious as those of other sustainability initiatives. This finding supports the view that stakeholders' perceptions of the benefits of sustainable buildings are influenced by their roles, responsibilities, and financial considerations. It may lead to different rankings among different groups.

Research supports this difference in views. A study in Sri Lanka found that construction professionals consider water conservation practices, such as leak detection, sub-metering, and proper planning, as essential for saving costs and improving environmental performance (Waidyasekara, Silva and Rameezdeen, 2016). It also shows that water efficiency is gaining importance due to water scarcity and rising utility costs. In Malaysia's commercial buildings, replacing inefficient fittings has resulted it clear savings in operational expenses while also improving sustainability performance (Zaini, Kwong and Jack, 2020). This makes water efficiency both an environmental and financial concern. The significant difference in ranking suggests that consultants and contractors recognize these dual benefits, while developers may underestimate the financial gains or view them as long-term rather than immediate. Providing stronger cost-benefit evidence and integrating water efficiency into project planning could help align stakeholder perspectives.

Table 4.6: Mean Score and Standard Deviation of Benefits of Sustainable Construction

Ref	Benefits	Overall (N=120)			Developer (N=30)			Consultant (N=33)			Contractor (N=57)			Chi-square	Asymp. Sig
		Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R		
	Environmental Benefits														
B1	Reduce Carbon Footprint	4.25	0.748	2	4.23	0.568	2	4.24	0.936	2	4.26	0.720	3	1.591	0.732
B2	Energy Efficiency	4.18	0.608	6	4.13	0.681	4	4.21	0.650	4	4.19	0.549	5	0.218	0.834
B3	Waste Reduction	4.20	0.729	3	4.20	0.664	3	4.21	0.820	5	4.19	0.718	6	0.650	0.914
B4	Water Efficiency	4.20	0.559	4	3.93	0.583	7	4.24	0.561	3	4.32	0.506	1	4.123	0.013*
B5	Better Use of Materials	4.04	0.803	8	3.83	0.791	8	4.21	0.740	6	4.05	0.833	8	4.475	0.145
	Social Benefits														
B6	Health Improvement	4.34	0.628	1	4.27	0.450	1	4.45	0.833	1	4.32	0.572	2	6.707	0.096
B7	Increased productivity, Staff Recruitment and Retention	3.93	0.724	9	3.83	0.747	9	3.85	0.755	9	4.02	0.694	9	2.134	0.517
B8	Enhance Comfort Condition inside the Building	4.10	0.600	7	4.00	0.525	6	4.18	0.635	7	4.11	0.618	7	2.621	0.455
	Economic Benefits														
B9	Lifecycle Cost Reduction	4.19	0.781	5	4.13	0.681	5	4.18	1.074	8	4.23	0.627	4	2.789	0.499

B10	Increase the Property Value	3.57	0.994	10	3.53	1.008	10	3.82	0.882	10	3.44	1.035	10	0.369	0.209

N = Sample size, SD = Standard Deviation, R=Rank

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

Table 4.7: Comparison of Benefits of Sustainable Construction with Previous Studies

Countries	Authors	Benefits of Sustainable Construction in Malaysia's construction industry				
		Health Improvement	Reduce Carbon Footprint	Waste Reduction	Water Efficiency	Lifecycle Cost Reduction
Greece	Vatalis et al. (2011)	✓		✓	✓	
Canada	Ruparathna and Hewage (2015)	✓	✓	✓	✓	✓
Sri Lanka	Athapaththu and Karunasena (2018)	✓		✓	✓	✓
Ghana	Ahiabu, Emuze and Das (2023)	✓	✓	✓	✓	✓
Nigeria	Esezobor (2016)	✓		✓		
United Kingdom	Ogunbiyi, Oladapo and Goulding (2014)	✓		✓	✓	
Malaysia	Hamid et al. (2012)	✓	✓	✓		✓
	Marhani, Jaapar and Bari (2012)	✓		✓	✓	
Total		8	3	8	6	4

4.8 Challenges of Sustainable Construction in Malaysia's construction industry

4.8.1 Mean Ranking

The mean and standard deviations of the sustainable construction challenges facing the Malaysian construction sector are shown in Table 4.8. A five-point Likert scale, with 1 indicating "strongly disagree" and 5 indicating "strongly agree," was used to ask respondents how much they agreed that these challenges occurred. In general, respondents agreed with the assertions, as indicated by the mean score for most variables being above 3.80, which is higher than the neutral midpoint of 3.00. This implies that the results are sufficient and provide significant new insights for the research. According to Table 4.8, which ranks the challenges of sustainable construction by mean and standard deviation, the top five difficulties are as follows:

(i) High Initial Cost (Mean = 4.32, δ = 0. 710)
(ii) Weak Policy Enforcement (Mean = 4.28, δ = 0.700)
(iii) Low Consumer Awareness (Mean = 4.21, δ = 0.697)
(iv) Lack of Financial Incentives (Mean = 4.19, δ = 0.737)
(v) Lack of Training and Skilled Labour (Mean = 4.05, δ = 0.798)

Firstly, high initial cost was ranked as the most significant challenge of sustainable construction. This reflects the common perception that sustainable building practices require greater upfront investment in materials, technologies, and design, which often discourages stakeholders despite the potential for long-term savings. Numerous studies confirm that high initial costs are a recurring barrier to sustainable construction, particularly in developing nations (Jaffar et al., 2022; Olatunde et al., 2025). For example, research in Malaysia has consistently identified cost as the primary deterrent to adopting green practices, as developers and contractors often prioritise short-term affordability over long-term benefits (Jaffar et al, 2022). Similarly, Olatunde et al. (2025) studied in Nigeria reported that stakeholders remain hesitant due to the higher capital requirements associated with energy-efficient systems and environmentally friendly materials. Despite these challenges, existing literature also highlights that while sustainable construction may incur additional initial costs, the long-term savings generated through reduced operational, maintenance, and energy costs outweigh these expenditures (Kats et al., 2003; Hamid et al., 2023). This suggests that the challenge lies not in the absolute cost but in the lack of awareness and financing mechanisms that could help industry players appreciate the lifecycle cost advantages of sustainable practices.

Moreover, "Weak Policy Enforcement" was ranked as the second most significant barrier to sustainable construction. This challenge arises when existing regulations and policies promoting sustainability are not effectively monitored, implemented, or enforced by the relevant authorities. Hassan et al. (2023) studied that the shift toward sustainable building practice is hindered by insufficient governmental incentives and a lack of rigorous enforcement mechanisms, even in the presence of supportive policies in Malaysia. Similarly, studies from Nigeria reveal that unclear policy directives and inadequate regulation enforcement undermine efforts to mainstream sustainable construction, especially in contexts where implementation strategies and stakeholder collaboration are weak (Babalola and Harinarain, 2024). At a broader governance level, overlapping responsibilities among federal, state, and local entities have led to fragmented oversight of sustainable development initiatives such as the National Physical Plan and the Low Carbon Cities Framework (Yaacub, Rong and Roslani, 2025). This misalignment has significantly diluted policy enforcement efficacy.

Then, the third-ranked challenge is "Low Consumer Awareness" among the ten identified barriers. This issue highlights the lack of understanding and knowledge among end-users, developers, and even some industry professionals regarding the long-term benefits of sustainable construction. Consumers often prioritize short-term affordability over environmental or lifecycle advantages, which discourages developers and contractors from adopting green building practices (Mazli and Fauzi, 2022). In Malaysia, studies show that awareness of sustainability remains relatively low compared to developed nations, where consumers are more informed about the ecological, health, and financial benefits of green buildings (Rezaee et al., 2024; Masyhur et al., 2024). As a result, demand for sustainable housing is weaker, making it less attractive for developers to invest in eco-friendly materials and technologies .

Next, “Lack of Financial Incentives” was ranked as the fourth major challenge to sustainable construction. One of the critical barriers for both developers and consumers is the absence of strong financial support mechanisms, such as tax reductions, subsidies, soft loans, or grants, that could help offset the high initial costs associated with green building practices (Masyhur et al., 2024). Without such incentives, many stakeholders perceive sustainable construction as economically unfeasible. In Malaysia, some incentives already exist, for example, the Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE) (Leong, 2017; Vimal, 2024). However, their impact is limited due to complex application procedures, narrow eligibility criteria, and inconsistent implementation. This explains why respondents in the study acknowledged financial incentives as an important issue but did not rank it higher than barriers such as high initial costs or weak policy enforcement.

Last but not least, “Lack of Training and Skilled Labour” is ranked as the fifth barrier in the overall ranking. This highlights the shortage of professionals, contractors, and workers equipped with the necessary knowledge and technical skills to implement sustainable construction practices effectively. Masyhur et al., 2024 stated that participation levels remain low compared to industry demand, although the Construction Industry Development Board (CIDB) and the Green Building Index (GBI) have introduced certification schemes and training programs. Many contractors and site workers are still more familiar with conventional methods, which hinders the integration of green technologies such as energy-efficient systems, recycled materials, and water-saving installations. As a result, the lack of skilled manpower contributes to higher costs, longer project timelines, and reluctance among developers to adopt sustainable practices (Masyhur et al., 2024).

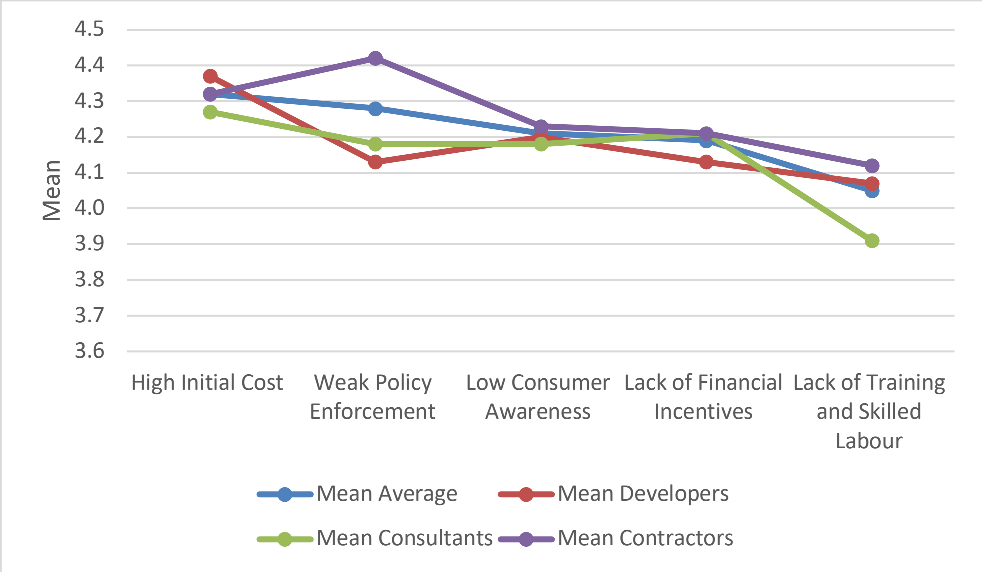

Figure 4.5: Profiles of Challenges for Mean Ranking Across Stakeholders

This graph illustrates the mean ranking profiles of barriers to sustainability adoption as perceived by different stakeholder groups—developers, consultants, contractors, and the overall average. The barriers evaluated include high initial cost, weak policy enforcement, low consumer awareness, lack of financial incentives, and lack of training and skilled labour. Among these, high initial cost emerged as the most significant barrier, with consistently high mean scores across all stakeholders, particularly developers. In contrast, lack of training and skilled labour was rated the lowest overall, with consultants assigning the lowest mean score relative to other groups. Notably, weak policy enforcement was emphasized more strongly by contractors, who rated it higher than both developers and consultants.

4.8.2 Comparison with Previous Studies

To strengthen the research findings, a comparison was made between the results of this study and those from other countries. Previous studies from Ghana, Oman, Vietnam, South Africa, India, and Singapore are summarised in Table 4.9. Based on this comparison, it is evident that other developing nations also recognise the top five barriers to sustainable construction identified in Malaysia. In particular, several prior studies conducted in all countries highlighted high initial cost as the most critical challenge to implementing sustainable practices. Although the present study focuses on Malaysia, the comparative analysis in Table 4.9 demonstrates that the barriers identified are consistent with those reported internationally. This consistency suggests that the obstacles to sustainable construction are not confined to Malaysia but are commonly experienced across developing economies. It also reinforces the reliability of the current findings, indicating that addressing these barriers requires broader strategies that can be adapted to various national contexts.

4.8.3 Kruskal-Wallis Test

The Kruskal-Wallis Test results indicate that there is no significant difference among developers, contractors, and consultants regarding the challenges of adopting sustainable construction. This suggests that all stakeholder groups perceive the challenges in a similar way, regardless of their distinct roles in the construction industry. Such a finding implies that barriers like high initial costs, lack of knowledge, weak enforcement of policies, and resistance to change are recognised as common obstacles by all parties. This finding is consistent with previous studies, which highlight that sustainability challenges in construction are often systemic issues affecting the entire industry rather than being tied to a single stakeholder group.

For instance, Darko et al. (2017) noted that the adoption of sustainable construction is universally hindered by high capital investment, a lack of knowledge, and a lack of supportive regulations, all of which are frequently mentioned by various stakeholders and in various countries. Similar findings were made by Hwang & Tan (2012), who discovered that cost and low awareness were equally important issues for Singapore's public and private sector actors.

Therefore, the absence of significant differences reinforces the notion that industry-wide collaborative solutions are required. Since all stakeholders face the same set of challenges, overcoming them will demand joint efforts, such as government incentives, industry training programs, and stronger policy enforcement, rather than isolated initiatives by one group.

Table 4.8: Mean Score and Standard Deviation of Challengs of Sustainable Construction

Ref	Challenges	Overall (N=120)			Developer (N=30)			Consultant (N=33)			Contractor (N=57)			Chi-square	Asymp. Sig
		Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R		
C1	Weak Policy Enforcement	4.28	0.700	2	4.13	0.629	3	4.18	0.917	3	4.42	0.565	1	4.149	0.133
C2	Lack of Knowledge on Sustainable Construction	3.92	0.862	9	3.93	0.785	7	3.91	0.843	6	3.93	0.923	9	0.553	0.941
C3	Low Consumer Awareness	4.21	0.697	3	4.20	0.714	2	4.18	0.727	4	4.23	0.682	3	0.041	0.971
C4	Lack of Training and Skilled Labour	4.05	0.798	5	4.07	0.691	6	3.91	0.879	7	4.12	0.803	5	2.681	0.495
C5	Lack of Professional Capabilities or Designers	3.86	0.901	10	3.90	0.548	8	3.91	0.91	8	3.81	1.043	10	4.446	0.870
C6	High Initial Cost	4.32	0.710	1	4.37	0.850	1	4.27	0.839	1	4.32	0.540	2	2.840	0.546
C7	Lack of Financial Incentives	4.19	0.737	4	4.13	0.860	4	4.21	0.820	2	4.21	0.619	4	0.962	0.891
C8	Resistance to Change	4.03	0.804	6	4.10	0.712	5	3.79	0.927	10	4.12	0.758	6	0.793	0.187
C9	Sustainable Materials Supply Chain Limitation	3.93	0.881	8	3.83	0.834	9	3.82	0.917	9	4.04	0.886	7	3.787	0.349
C10	Long Payback Periods from Sustainable Practices	3.93	0.786	7	3.77	0.858	10	4.06	0.827	5	3.95	0.718	8	3.659	0.365

N = Sample size, SD = Standard Deviation, R=Rank

Table 4.9: Comparison of Challenges of Sustainable Construction with Previous Studies

Countries	Authors	Challenges of Sustainable Construction in Malaysia's construction industry				
		High Initial Cost	Weak Policy Enforcement	Low Consumer Awareness	Lack of Financial Incentives	Lack of Training and Skilled Labour
Ghana	Ametepeya, Aigbavboab and Ansahb (2015)	✓	✓	✓	✓	✓
	Ametepey, Asiedu and Kissiedu (2015)	✓	✓	✓		✓
Oman	Saleh and Alalouch (2015)	✓		✓	✓	
Vietnam	Pham, Kim and Luu (2019)	✓		✓	✓	✓
South Africa	Aigbavboa, Ohiomah and Zwane (2017)	✓		✓		
Indian	Tathagat and Dod (2015)				✓	✓
	Gehlot and Shrivastava (2021)	✓	✓			
Singapore	Chua et al. (2018)	✓			✓	
Malaysia	Jamaludin, Mahayuddin and Hamid (2017)	✓		✓	✓	✓
Total		8	3	6	6	5

4.9 Strategies for Adopting of Sustainable Construction in Malaysia's construction industry

4.9.1 Mean Ranking

The mean and standard deviations of the strategies for adopting sustainable construction in the Malaysian construction sector are presented in Table 4.10. Respondents were asked, using a five-point Likert scale 1 = "Not at All" and 5 = "Very Significantly", to indicate the extent to which they agreed these strategies were effective. Overall, the results show a positive response, with most strategies scoring mean values above 3.80, which is higher than the neutral midpoint of 3.00. This indicates that respondents generally considered the proposed strategies to be effective, thus providing valuable insights into approaches that could enhance the implementation of sustainable construction. Based on the ranking of mean and standard deviation in Table 4.10, the top five strategies for adopting sustainable construction are identified as follows:

(i) Increase Incentives for Sustainable Construction (Mean = 4.38, δ = 0. 662)
(ii) Improve the Regulations and Policies of Sustainable Construction (Mean = 4.25, δ = 0.812)
(iii) Loan with Low Interest Rate to Green Building (Mean = 4.25, δ = 0.689)
(iv) Encouraging Sustainable Construction Research (Mean = 4.21, δ = 0.777)
(v) Building Information Modelling (BIM) (Mean = 4.21, δ = 0.744)

First of all, "Increase Incentives for Sustainable Construction" is identified as the most significant strategy in this study, with a mean 4.38. This indicates that respondents strongly believe financial and non-financial incentives play a crucial role in motivating contractors, developers, and consultants to adopt sustainable practices. Masyhur et al. (2024) identifies financial incentives as one of the key motivation for uplifting adoption of green construction practices in Malaysia. However, they also observed that despite existing national policies, the level of adoption remains relatively low, partly due to insufficient incentive schemes. Their study therefore recommended enhancing financial incentives to accelerate industry-wide adoption. Similarly, Chan, Darko, and Ameyaw (2017) demonstrated in their global study that "financial and market-based incentives" are consistently ranked among the most influential strategies for encouraging the adoption of green building technologies (GBTs). Although their research was not limited to Malaysia, it reinforces the notion that incentive mechanisms are universally critical in driving sustainable construction practices. The convergence of both local and international findings underscores the importance of incentive-driven approaches. For Malaysia, this means that expanding tax allowances, subsidies, soft loans, and recognition programs could serve as strong catalysts for increasing participation in sustainable construction (Ahzahar et al., 2022).

Furthermore, "Improve the Regulations and Policies of Sustainable Construction" is ranked as the second most significant strategy in this study. This finding aligns with the previous studies which highlighted that respondents perceive stronger regulatory frameworks and clearer policies as essential for ensuring the effective implementation of sustainable construction practices (Akindele et al., 2023; Hafez et al., 2023; Akreim and Suzer, 2018). In Malaysia, although several policies such as the Construction Industry Transformation Programme (CITP 2016–2020), Green Building Index (GBI), and the National Green Technology Policy have been introduced, enforcement has often been inconsistent, leading to slow adoption rates (Yaman and Ghadas, 2020). Darko and Chan (2018) emphasised that, globally, improved policy frameworks and stronger regulatory measures are among the most influential strategies in driving the adoption of green building technologies. This suggests that enhancing regulations in Malaysia not only provides a structured framework but also ensures accountability, making sustainable construction practices more mainstream.

Third, "Loan with Low Interest Rate to Green Building" is ranked as the third most significant strategy in this study. This reflects that respondents see access to affordable financing as a key factor in overcoming the high upfront costs associated with sustainable construction. Green technologies and certified building materials often require significant initial investments, which can deter contractors and developers. Providing loans with lower interest rates can reduce these barriers and make green projects more financially feasible (Agyekum, Goodier and Oppon, 2021). Lee et al. (2013) offer a model that supports this strategy by proposing a financing scheme in which the government provides guarantees for the increased costs of green building projects in return for Certified Emission Reductions (CER). This guarantee helps to reduce risk for lenders, which in turn could make it possible to offer more favourable, lower-interest loans or credit terms because the risk premium is lowered (Lee et al., 2013).

After that, the fourth rank is "Encouraging Sustainable Construction Research" among the 20 strategies identified in this study. Research not only supports the advancement of eco-friendly building materials and energy-efficient systems but also provides empirical evidence that helps policymakers, developers, and contractors make informed decisions (Shan, Hwang and Zhu, 2017). Pitt et al. (2009) reinforce this perspective in their study, where they argue that research and demonstration projects are critical enablers of sustainable construction adoption. Their findings emphasize that successful promotion of sustainability in construction requires not only strong regulations and incentives but also sustained investment in research to identify best practices, assess performance outcomes, and build industry confidence. This aligns with the present study's results, where respondents acknowledge that encouraging research can accelerate innovation and provide the technical solutions necessary to reduce costs, improve efficiency, and increase acceptance of sustainable construction practices.

Lastly, the fifth strategy is the use of Building Information Modelling (BIM) in sustainable construction. This reflects the growing recognition among respondents that digital technologies can significantly enhance the adoption of sustainable practices. BIM helps combine design, construction, and operating data into one platform (Ferdosi et al., 2022). This enables stakeholders to assess the project's environmental performance, optimize material use, and minimize waste throughout the project lifecycle. Wong and Zhou (2015) demonstrate that green BIM promotes environmental sustainability by facilitating life cycle assessments, enhanced energy modeling, and the integration of sustainability metrics from the early stages of project design, thereby improving environmental outcomes. Cao, Kamaruzzaman, and Aziz (2022) conducted a systematic review showing that BIM improves project quality, lifecycle data management, collaboration, planning, and scheduling in green building construction. In the Malaysian context, Zulkefli, Mohd-Rahim, and Zainon (2020) find that BIM can serve as an enabler for greening existing non-green buildings, helping optimize energy performance, reduce material and waste usage, and enhance overall sustainability metrics.

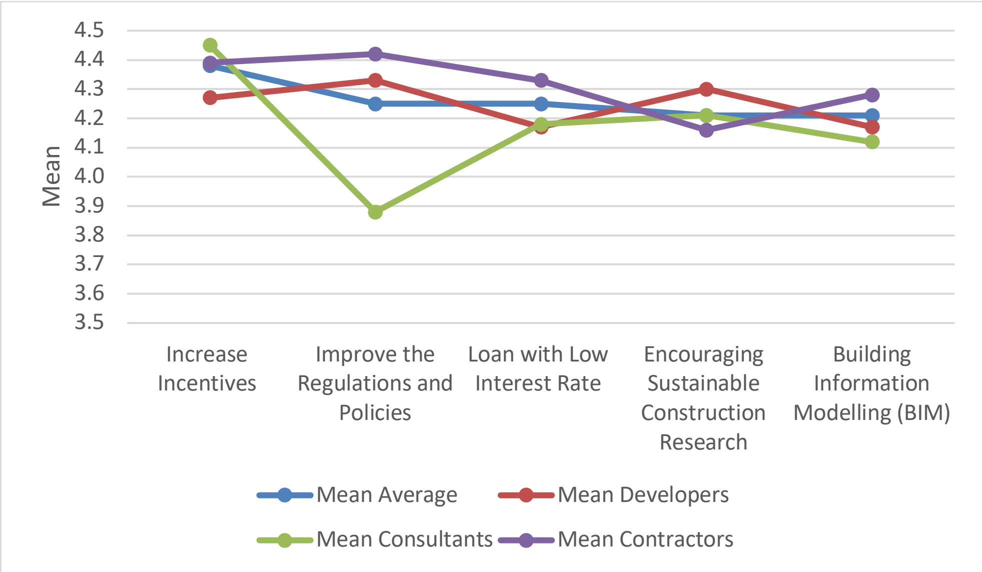

Figure 4.6: Profiles of Strategies for Mean Ranking Across Stakeholders

This graph depicts the mean ranking of strategies to enhance sustainability adoption as perceived by different stakeholder groups. The strategies examined include increasing incentives, improving regulations and policies, offering loans with low interest rates, encouraging sustainable construction research, and adopting Building Information Modelling (BIM). Among these, increasing incentives received the highest overall ratings, particularly from consultants, who placed it well above other strategies. Improving regulations and policies was rated most highly by contractors, reflecting their emphasis on policy-driven measures. By contrast, consultants gave the lowest rating to this same factor, highlighting a notable divergence in stakeholder perspectives. Encouraging sustainable construction research and BIM adoption were rated moderately by all groups, with relatively less variation, while low-interest loans received steady mid-level support across stakeholders.

4.9.2 Comparison with Previous Studies

To reinforce the research findings, this study compared its results with those from other countries. Previous research conducted in Ghana, Nigeria, China, and the United Kingdom is presented in Table 4.11. Based on the comparison, it's clear that developing countries agree with the top five ways that Malaysia has found to use sustainable building practices. Notably, many studies in these countries stress that "Encouraging Sustainable Construction Research" and "Increase Incentives for Sustainable Construction" are two of the most important ways to promote sustainable practices. Although this study focuses solely on Malaysia, Table 4.11's comparative analysis reveals that the methods identified are consistent with those found in other countries. This alignment indicates that the challenges of sustainable construction are not unique to Malaysia but are shared across developing economies. Consequently, the reliability of the current findings is strengthened, suggesting that overcoming these barriers requires comprehensive strategies adaptable to diverse national contexts.

4.9.3 Kruskal-Wallis Test

The Kruskal-Wallis Test was conducted to test whether there is a significant difference in the ranking of those 20 strategies for adopting sustainable construction among contractors, consultants and developers. Table 4.10 shows that there is no significant difference across stakeholders for most strategies of sustainable construction, except for “Improve the Regulations and Policies of Sustainable Construction” and “Collaboration with Outsiders.” Both developers and contractors ranked “Improve the Regulations and Policies of Sustainable Construction” as the second most important strategy in this study, while consultants placed it much lower at 16th.

This difference may reflect the consultants' focus on technical implementation and project execution, where regulatory frameworks may not be perceived as a direct driver compared to design or operational considerations. On the other hand, developers and contractors, who are more exposed to regulatory compliance and approval processes, consider strong regulations and policies as crucial to facilitating sustainable construction. As studies such as Residential building developers' perspective (Malaysia) have found, regulations and building codes are viewed by developers as major external drivers for sustainable construction adoption (Mahat, Tah and Vidalakis, 2019). Since non-compliance can lead to delays, additional costs, or reputational issues, these stakeholder groups perceive regulations as essential.

For "Collaboration with Outsiders," consultants ranked it highly at 4th place, whereas developers and contractors placed it much lower at 20th. This discrepancy likely reflects the different roles and incentives of these stakeholder groups. Consultants, who often work across multiple projects and are exposed to external innovation, research, and sustainability trends, tend to value collaboration with external experts, NGOs, and specialists. This allows them to access complementary resources, knowledge sharing, and credibility in adopting sustainable construction methods. On the other hand, developers and contractors may see less direct benefit from external collaboration. Their priorities tend to lean towards immediate project delivery, cost control, and regulatory compliance. This is because external collaboration may introduce additional coordination, delays, or unfamiliar inputs, these groups might perceive it as less essential unless it clearly contributes to profitability or regulatory compliance. Therefore, the difference in ranking suggests that promotion of collaboration should be tailored: consultants may push for more open partnerships and knowledge networks, while developers and contractors might need clearer incentives or demonstrated returns to elevate collaboration as a higher priority in sustainable construction adoption.

Table 4.10: Mean Score and Standard Deviation of Strategies for Adoption Sustainable Construction

Ref	Strategies	Overall (N=120)			Developer (N=30)			Consultant (N=33)			Contractor (N=57)			Chi-square	Asymp. Sig
		Mean	SD	R	Mean	SD	R	Mean	SD	R	Mean	SD	R		
S1	Increase Incentives for Sustainable Construction	4.38	0.662	1	4.27	0.583	1	4.45	0.794	1	4.39	0.620	1	2.871	0.228
S2	Increase the Awareness of Sustainable Construction for Public	4.09	0.756	12	4.00	0.695	14	4.03	0.847	12	4.18	0.735	6	1.343	0.397
S3	Encouraging Sustainable Construction Research	4.21	0.777	4	4.30	0.651	3	4.21	0.857	2	4.16	0.797	8	0.492	0.773
S4	Improve the Regulations and Policies of Sustainable Construction	4.25	0.812	2	4.33	0.711	2	3.88	0.960	16	4.42	0.706	2	8.534	0.011*
S5	Provide Training for Construction Workers and Professional	4.11	0.671	11	4.17	0.379	7	4.21	0.78	3	4.02	0.719	15	3.901	0.256
S6	Building Information Modelling (BIM)	4.21	0.744	5	4.17	0.747	8	4.12	0.820	6	4.28	0.701	4	1.204	0.594
S7	Improve Rating Tools and Certificate System	4.04	0.824	14	4.03	0.615	13	3.88	0.992	17	4.14	0.811	11	3.310	0.381
S8	Enhancement of Green Building Codes	4.12	0.822	10	4.10	0.803	11	4.06	0.864	11	4.16	0.819	9	0.641	0.857
S9	Modular Prefabrication	4.13	0.697	8	4.23	0.626	5	3.97	0.847	14	4.18	0.630	7	1.187	0.411
S10	Internet of Things (IoT)	4.16	0.756	6	4.27	0.740	4	4.09	0.765	9	4.14	0.766	12	1.202	0.594

S11	Collaboration with Outsiders	3.83	0.976	20	3.57	0.971	20	4.21	0.740	4	3.74	1.044	20	4.657	0.022*
S12	Promoting Sustainable Construction In Private Sector	4.03	0.766	15	4.00	0.830	15	4.12	0.740	7	4.00	0.756	16	0.627	0.758
S13	Market Creation for Sustainable Construction Materials	3.88	0.865	18	3.73	0.980	19	3.97	0.847	15	3.89	0.817	18	0.327	0.609
S14	Smart Building	4.13	0.634	9	4.23	0.679	6	4	0.750	13	4.16	0.527	10	1.510	0.362
S15	Integrated Project Delivery Method	4.09	0.635	13	4.1	0.548	12	4.09	0.678	10	4.09	0.662	13	0.250	0.990
S16	Loan with Low Interest Rate to Green Building	4.25	0.689	3	4.17	0.699	9	4.18	0.727	5	4.33	0.664	3	1.458	0.439
S17	Demonstration Project and Case Studies	3.89	0.877	17	3.83	0.834	18	3.88	1.023	18	3.93	0.821	17	1.227	0.775
S18	Environmental Impact Assessment	4.16	0.722	7	4.13	0.819	10	4.12	0.65	8	4.19	0.718	5	0.666	0.796
S19	Consolidation of the Role of Green Building Councils	3.96	0.782	16	3.97	0.809	16	3.76	1.001	19	4.07	0.593	14	0.198	0.482
S20	Establish More Green Building Associations	3.86	0.863	19	3.9	0.960	17	3.76	0.867	20	3.89	0.817	19	2.256	0.712

N = Sample size, SD = Standard Deviation, R=Rank

Note:

*. The mean difference is statistically significant at the 0.05 level (p < 0.0)

Table 4.11: Comparison of Strategies for Adopting Sustainable Construction with Previous Studies

Countries	**Authors**	**Strategies for Adopting Sustainable Construction in Malaysia's construction industry**				
		Increase Incentives for Sustainable Construction	Improve the Regulations and Policies of Sustainable	Loan with Low Interest Rate to Green Building	Encouraging Sustainable Construction Research	Building Information Modelling (BIM)
Ghana	Agyekum, Goodier and Oppon (2021)	✓	✓	✓		
	Darko et al. (2018)	✓	✓		✓	
Nigeria	Omopariola et al. (2022)	✓			✓	✓
China	Chang et al. (2016)		✓		✓	
United Kingdom	Alwan, Jones and Holgate (2016)	✓			✓	✓
Malaysia	Shari and Soebarto (2012)	✓	✓	✓	✓	
Total		5	4	2	5	2

4.10 Factor Analysis

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

The suitability of the data for factor analysis was first assessed using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity. As shown in Table 4.12, the KMO value was 0.862, which exceeds the minimum threshold of 0.60 and is considered excellent sampling adequacy (Pallant, 2013), indicating that the sample size and correlations among variables were sufficient for factor analysis. In addition, Bartlett's Test of Sphericity produced a highly significant result ($\chi^2 = 910.329$, df = 190, $p < 0.001$), confirming that the correlation matrix was not an identity matrix and that the variables were adequately intercorrelated (Glen, 2016). Together, these results support the appropriateness of proceeding with principal component analysis.

Table 4.12: Results of KMO and Bartlett's Tests

Parameter	Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.862
Bartlett's Test of Sphericity	
Approximate Chi-Square	910.329
Degree of freedom	190
Significance	<.001

According Braeken and Assen (2017), the number of underlying factors was determined using Kaiser's criterion together with visual inspection of the scree plot (Figure 4.4) . The scree plot shows a noticeable break after the fifth component, suggesting that the first five components capture the most meaningful variance, while the remaining components have eigenvalues below 1.00 and contribute minimally to the overall explanation of the data. The retained five-factor solution explains 61.054% of the total variance, which exceeds the commonly recommended 60% benchmark for behavioural and management research, indicating that the model captures a substantial proportion of the shared variance in the dataset (Sigudla & Maritz, 2023). Taken together with the strong KMO and significant Bartlett's test reported earlier, this provides evidence that the extracted factor structure is stable and appropriate for interpretation. Variables were subsequently allocated to factors based on their loadings using a minimum threshold of 0.40 to ensure a clear and interpretable solution. Any item scoring below this threshold was excluded from the factor grouping. In this study, the item "Improve rating tools and certificate system" recorded a loading of less than 0.40, and therefore was dropped from the underlying factor structure.

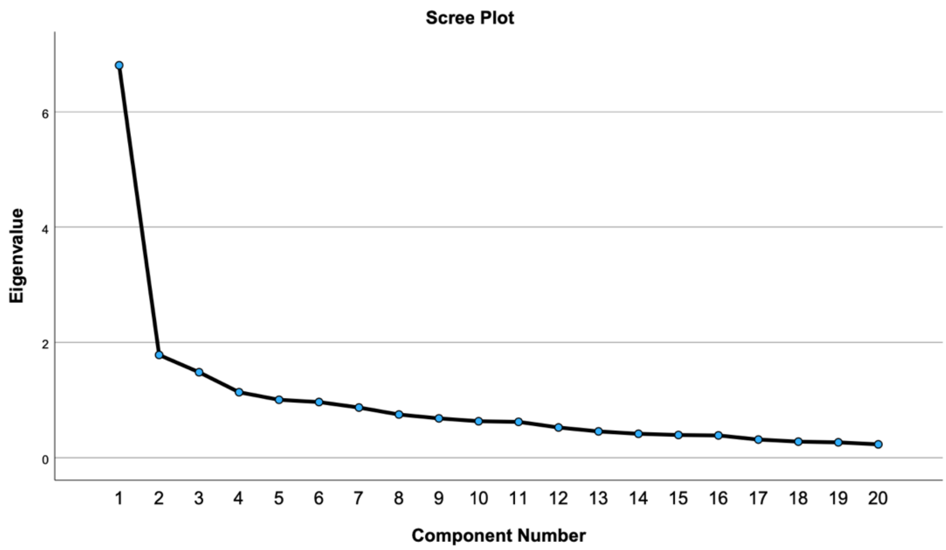

Figure 4.7: Scree Plot for 20 Strategies for Adoption Sustainable Construction

Table 4.13: Interpretation of Total Variance.

Component	Rotation Sums of Squared Loadings		
	Total	Percentage Of Variance (%)	Cumulative Percentage (%)
F1	2.781	13.904	13.904
F2	2.631	13.155	27.059
F3	2.425	12.124	39.183
F4	2.232	11.161	50.344
F5	2.142	10.710	61.054

Table 4.14: Factor Loading and Variance Explained

	Factor Loading	**Variance Explained (%)**
Factor 1: Capacity Building and Innovation		
Increase incentives for sustainable construction	0.823	13.904
Provide sustainable construction training for construction workers and professional	0.691	
Modular prefabrication	0.577	
Enhancement of Green Building Codes	0.560	
Increase the awareness of sustainable construction for public	0.518	
Building Information Modelling (BIM)	0.499	
Factor 2: Innovative Financing and Smart Delivery Approaches		
Loan with low interest rate to Green Building	0.728	13.155
Integrated Project Delivery Method	0.696	
Internet of Things (IoT)	0.608	
Smart Building	0.603	
Factor 3:Institutional and Organisational Support		
Consolidation of the role of Green Building Councils	0.818	12.124
Establish more Green Building Associations	0.817	
Demonstration project and case studies	0.615	
Factor 4: Policy and Environmental Governance		
Encouraging sustainable construction research	0.745	11.161

Environmental Impact Assessment	0.644	
Improve the regulations and policies of sustainable construction	0.474	
Factor 5:Collaboration and Market Development		
Collaboration with outsiders	0.786	10.710
Market creation for sustainable construction materials	0.655	
Promoting sustainable construction in private sector	0.639	
Cumulative variance explained		61.054

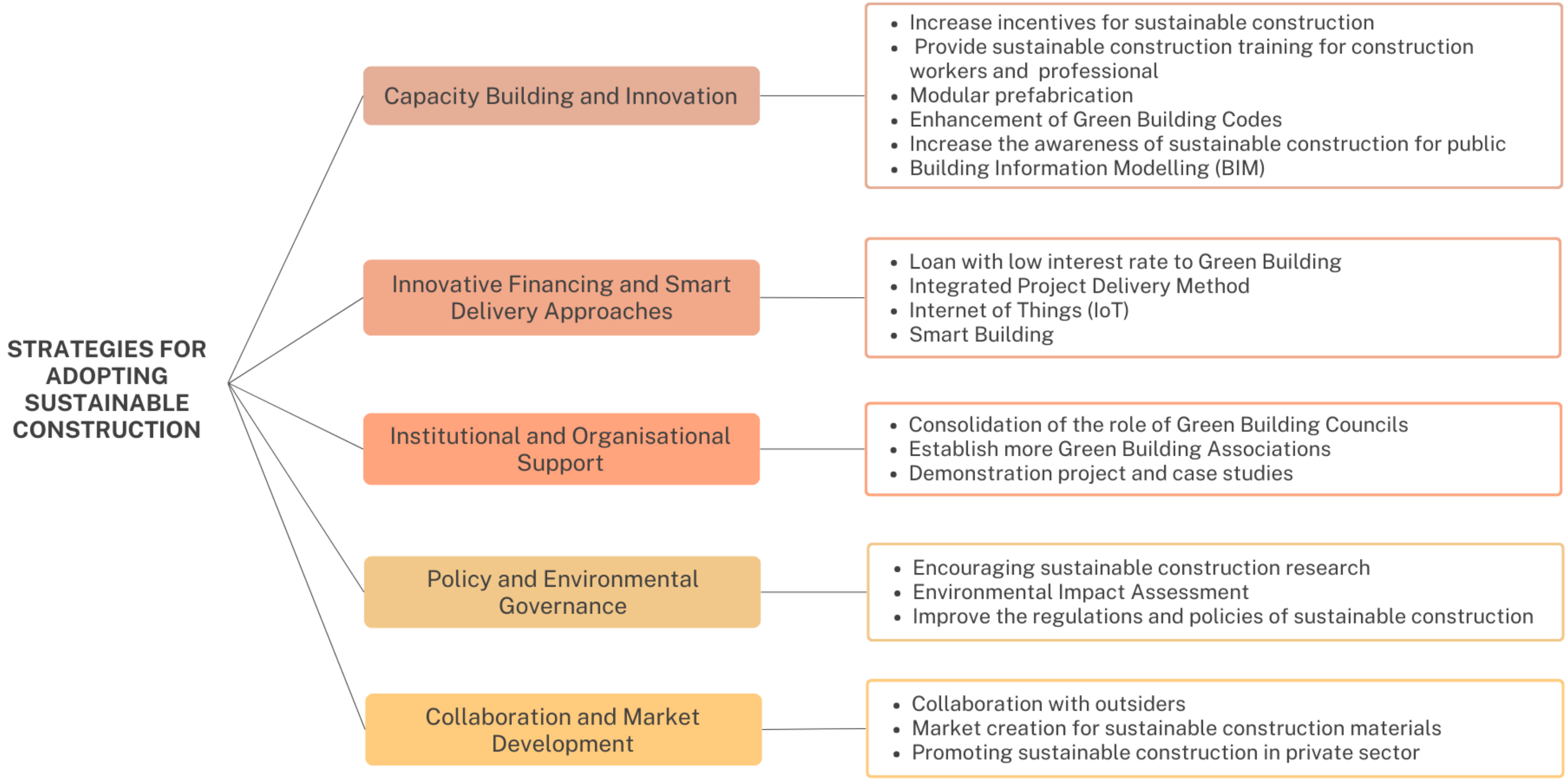

Figure 4.8: Factor Profile for 20 Strategies for Adopting Sustainable Construction in Malaysia's construction industry

4.10.2 Extraction of Underlying Factor

Factor 1: Capacity Building and Innovation

The main strategy cluster for advancing sustainable construction in Malaysia is Capacity Building and Innovation, which accounts for 13.90% of the total variance explained. This element emphasizes how crucial it is to develop technical skills, support innovation, and fortify human resources as key facilitators of the adoption of sustainability. It reflects the conviction that the shift to sustainable construction will remain restricted in the absence of adequate education, awareness, and cutting-edge resources. Capacity building and innovation comprises six variables, including ‘Increase incentives for sustainable construction’, ‘Provide sustainable construction training for construction workers and professional’, ‘Modular prefabrication’, ‘Enhancement of Green Building Codes’, ‘Increase the awareness of sustainable construction for public’ and ‘Building Information Modelling (BIM)’. Prior research has also shown that technological innovation and capacity building are crucial tactics for promoting sustainable building practices in both developed and developing countries (Chan, Darko, and Ameyaw, 2017). This factor's importance stems from its capacity to bridge the innovation and knowledge gaps that frequently impede sustainable practices. According to Meena et al. (2012), funding for education, awareness-raising initiatives, and cutting-edge technologies not only improves technical proficiency but also shifts stakeholders' perspectives toward adopting green practices.

This variable, with the highest factor loading, illustrates that incentives are the most powerful driver for sustainable adoption. Incentives, both financial (e.g., tax rebates, low-interest financing, subsidies) and non-financial (e.g., recognition awards, fast-track approvals), motivate stakeholders to incorporate sustainable methods despite higher upfront costs (Olubunmi, Xia and Skitmore, 2016). By rewarding adoption, incentives encourage firms to invest in green technologies and sustainable processes. Empirical studies confirm that financial incentives are among the most effective mechanisms to drive sustainable construction uptake globally (Chan, Darko and Ameyaw, 2017). In Malaysia, although schemes such as the Green

Technology Financing Scheme (GTFS) have been introduced, uptake remains modest due to insufficient awareness and limited accessibility for small contractors (Ludin et al., 2013). Therefore, strengthening and diversifying incentive mechanisms is critical to increasing adoption rates.

Moreover, training ensures that both skilled and semi-skilled workers are familiar with sustainable methods, materials, and tools. Uddin et al. (2025) emphasised that knowledge transfer through training reduces implementation barriers while increasing efficiency and acceptance among contractors and consultants. In Malaysia, CIDB has initiated various training programs to upskill workers, but Wahab et al. (2022) highlight that participation rates remain low. Misconceptions regarding cost and technical viability endure in the absence of systematic training, underscoring the significance of organised capacity-building programs. At the same time, raising public awareness of sustainable building practices is equally important for boosting demand in the market and promoting broader adoption. Consumer preferences are shaped by awareness campaigns, which encourage developers to incorporate green features in order to satisfy market demands. According to Chan, Darko, and Ameyaw (2017), developers are more inclined to cover upfront expenses when end users value sustainable features like energy efficiency and healthier indoor environments.

On the technological side, modular prefabrication and Building Information Modelling (BIM) reflect the innovative solutions that improve efficiency, reduce waste, and enhance project performance (Lu and Korman, 2010). Prefabrication shortens timelines and minimises site disturbance, while BIM provides an integrated platform to evaluate environmental impacts and optimise resource use across a building's lifecycle. Together, these innovations represent practical tools for embedding sustainability into construction practice (Lu and Korman, 2010). Finally, the enhancement of green building codes acts as an institutional backbone, ensuring that the above efforts are properly standardised and enforced. Stronger regulations that are in line with global standards offer assurance and responsibility, turning sustainable practices into a legal necessity rather than an elective (Suh, 2014).

Overall, Capacity Building and Innovation emphasizes that industry stakeholders' internal capabilities must be strengthened in addition to external policies or funding for the adoption of sustainable construction. The construction industry can overcome long-standing obstacles and make the shift to sustainable development by combining incentives, training, creativity, awareness, and cutting-edge technologies like BIM and prefabrication.

Factor 2: Innovative Financing and Smart Delivery Approaches

Accounting for 13.15% of the total variance explained, Innovative Financing and Smart Delivery Approaches emerge as a critical construct for advancing sustainable construction. It includes ‘Loan with low interest rate to Green Building’, ‘Integrated Project Delivery Method’, ‘Internet of Things (IoT)’ and ‘Smart Building’. This factor reflects the importance of alternative financing mechanisms and modern project delivery technologies in overcoming cost-related barriers and improving project efficiency. Since high upfront costs and fragmented delivery methods often hinder sustainability adoption, addressing these areas is vital to ensuring long-term feasibility.

The first variable, “Loan with Low Interest Rate to Green Building”, represents the strongest loading under this factor. Access to affordable financing reduces the burden of high initial costs associated with green technologies and certified building materials, making sustainable projects more financially viable. Ayoungman et al. (2025) stress that concessional financing mechanisms can significantly influence developers’ willingness to adopt sustainable practices. In Malaysia, however, green financing initiatives are still relatively limited to selected government schemes and financial institutions, which underscores the need for broader policy support.

Complementing financial measures, Integrated Project Delivery Method (IPD) enhances collaboration among stakeholders by aligning interests and promoting shared responsibilities. Unlike traditional procurement systems that often create adversarial relationships, IPD fosters cooperation, reduces delays, and integrates sustainability goals into project decision-making. Studies by Newton et al. (2019) demonstrate that IPD when combined with digital tools has proven effective in delivering green building projects with higher efficiency.

The third and fourth variables involve smart technologies, including IoT and Smart Buildings. IoT allows real-time monitoring of energy use, air quality, and resource consumption. Abdul-Qawy (2015) notes that IoT improves facility management, lowers operational costs, and ensures environmental performance is tracked. Smart Buildings add automation, energy-efficient systems, and digital controls to optimize energy use and create healthier environments (Dakheel, 2020). While countries such as China and Singapore have made these technologies common (Zhan et al., 2023), Malaysia is still in the early stages. High costs and limited expertise remain barriers. Even so, with the growth of smart city initiatives, adoption of IoT and Smart Buildings is expected to rise.

In summary, Innovative Financing and Smart Delivery Approaches highlight the dual need to reduce financial barriers and modernize project delivery methods in order to accelerate sustainable construction. Affordable financing, collaborative delivery models, and smart technologies work in tandem to improve the feasibility and long-term benefits of green projects. This reinforces that economic support and technological advancement are inseparable pillars for driving sustainability transformation in the Malaysian construction industry.

Factor 3: Institutional and Organisational Support

Institutional and Organisational Support explains 12.12% of the total variance. It is a key factor because it shows how institutions, industry associations, and demonstration platforms create an environment that supports sustainable construction. Unlike individual or firm-level initiatives, institutional and organizational support provides long-term structural backing, which is essential for the continuity and scalability of sustainable construction. In institutional and organisational support, including ‘Consolidation of the role of Green Building Councils’, ‘Establish more Green Building Associations’ and ‘Demonstration project and case studies’.

The variables "Consolidation of the Role of Green Building Councils" and "Establish More Green Building Associations" represent the strongest loadings within this factor. Together, they highlight the importance of strengthening formal institutions that advocate, regulate, and guide sustainable construction practices. In Malaysia, the Malaysia Green Building Council and Green Building Index (GBI) have been instrumental in introducing certification schemes and promoting awareness. However, their impact remains limited due to resource constraints and low market penetration (Wei, 2020; Abd Hadi, 2024). Expanding the number and capacity of such institutions would amplify outreach, provide consistent industry standards, and facilitate international knowledge transfer (Wei, 2020).

In addition, Demonstration Projects and Case Studies also load strongly within this factor. Demonstration projects act as proof-of-concept platforms that showcase the economic and environmental feasibility of sustainable construction. Studies by Darko and Chan (2018) argue that visible pilot projects significantly influence stakeholders' perceptions by providing tangible evidence of benefits, thus reducing skepticism and resistance. Case studies also serve as a valuable learning tool, offering insights into best practices, challenges, and cost-benefit analyses. In Malaysia, examples such as the Energy Commission Diamond Building has demonstrated measurable improvements in energy efficiency, yet such projects remain relatively few compared to the broader construction sector (Fan, 2020). Scaling up demonstration efforts would further normalize sustainable construction practices and encourage adoption across different project types.

In conclusion, Institutional and Organisational Support underscores the necessity of building strong governance structures, professional networks, and demonstrative evidence to accelerate the adoption of sustainable construction. Green building councils, associations, and pilot projects together provide the institutional legitimacy, technical expertise, and real-world validation needed to drive systemic change. This reinforces that sustainability in construction is not solely dependent on individual firms but requires collective institutional action and continuous organisational reinforcement.

Factor 4: Policy and Environmental Governance

Policy and Environmental Governance explain 11.16% of the total variance. It is a critical factor because it shows how rules, safeguards, and government action drive sustainable construction. Strong governance gives the foundation for industry practices and market initiatives to grow. Without clear regulations and enforcement, efforts to promote sustainability often stay fragmented and voluntary. This factor includes three variables: Encouraging Sustainable Construction Research, Environmental Impact Assessment (EIA), and Improving Regulations and Policies of Sustainable Construction.

The first variable, "Encouraging Sustainable Construction Research" (0.745), has the highest loading. It highlights the need for evidence-based policymaking and innovation. Research provides both knowledge and data to guide policies, standards, and guidelines. Abidin (2010) and Darko et al. (2017) note that governments supporting research create conditions where best practices can spread. In Malaysia, agencies such as CIDB and SEDA, together with universities, have studied energy efficiency, carbon reduction, and green materials. However, the translation of research into practice is still limited. Strengthening collaboration between universities, policymakers, and industry players can help ensure that research outcomes directly inform regulatory reforms and market applications.

The second variable, Environmental Impact Assessment (EIA), shows the importance of governance tools that predict, assess, and reduce environmental risks (Selvakumar and Jeykumar, 2015). EIAs are more than procedures. They bring environmental concerns into early project planning. Studies such as Selvakumar and Jeykumar (2015) emphasize that effective EIAs can reduce negative ecological outcomes and guide developers towards more sustainable alternatives. In Malaysia, while EIAs are mandatory for large-scale developments, concerns have been raised about enforcement, monitoring, and post-approval compliance (Selvakumar and Jeykumar, 2015). Enhancing the robustness of EIAs, ensuring transparency, and incorporating lifecycle sustainability metrics could elevate their role as a governance tool in construction.

The third variable, “Improving Regulations and Policies of Sustainable Construction,” has a lower loading but remains important. Policies create the environment that turns sustainability into a standard practice instead of a voluntary choice. Chan et al. (2018) and Agyekum et al. (2020) argue that weak enforcement and inconsistent policies are major global barriers. In Malaysia, policies such as the National Green Technology Policy (2009) and Green Building Index guidelines exist, but enforcement is uneven. Stronger frameworks, mandatory performance standards, and clear compliance rules are needed to increase adoption across the industry.

In conclusion, Policy and Environmental Governance shows that sustainability in construction needs more than incentives. It requires strong rules, effective EIAs, and continuous research to guide decisions. This factor stresses that governance is the backbone of sustainable construction, ensuring accountability, consistency, and long-term protection of the environment.

Factor 5: Collaboration and Market Development

Collaboration and Market Development explains 10.71% of the total variance. It is an important factor because it shows how partnerships, private sector support, and market growth help the shift toward sustainable construction. This factor has three main parts: Collaboration with Outsiders, Market Creation for Sustainable Construction Materials, and Promoting Sustainable Construction in the Private Sector. Together, these parts show that sustainability depends on joint effort and strong market demand for green practices.

The strongest part is “Collaboration with Outsiders.” It shows the value of working across sectors and borders. Partnerships with international organisations, NGOs, universities, and industry leaders help local contractors and developers learn new knowledge. They also gain access to global practices, new technology, and financial models. Attah et al. (2024) state that joint ventures and partnerships speed up the use of sustainable methods because they share risks and close knowledge gaps.

Market creation for sustainable materials shows the need to build strong supply chains. It also shows the need to make eco-friendly products available at fair prices (Yahia and Shahjalal, 2024). Market demand drives the spread of green practices. Without enough demand, eco-products stay expensive and niche. In Malaysia, the Green Product Directory and green procurement policies support certified products. Still, low awareness and higher prices limit growth (Wang et al., 2021; Runtuk, Ng and Ooi, 2024).

"Promoting Sustainable Construction in the Private Sector" shows the role of developers, contractors, and investors. The government can give rules and incentives. But the private sector must drive adoption. Darko and Chan (2018) note that private firms often set trends. They do this by using green building certifications, testing new designs, and meeting consumer demand. In Malaysia, firms like Gamuda Land and SP Setia use sustainable methods to prove their benefits. Yet many SMEs avoid them because of cost concerns and lack of skills.

In conclusion, Collaboration and Market Development show that sustainability needs more than rules and money. It needs partnerships, stronger markets for green materials, and active private sector support. This factor shows that top-down policies and bottom-up market action must work together. This mix of collaboration and market development helps sustainable construction grow and last.

4.11 Spearman's Correlation Test

In Table 4.15, it shows the result of Spearman's correlation test. It was conducted to evaluate the relationship between the 10 challenges of sustainable construction (C1-C10) and 20 strategies for adopting sustainable construction in Malaysia's construction industry (S1-S20). Yan et al. (2019) classify a relationship as extremely strong if the coefficient is 0.80 or above, strong if it ranges from 0.60 to 0.79, moderate if it falls between 0.40 and 0.59, weak if it is between 0.20 and 0.39, very weak if it lies between 0 and 0.19, and indicate no correlation if it equals 0. This study indicates that the variables demonstrate a weak to moderate correlation. The strongest correlation between challenges and strategies for adopting sustainable construction is “Weak Policy Enforcement” (C1) and “Increase Incentives for Sustainable Construction” (S1).

Most strategies showed many strong relationships, while only a few had weaker links. Strategy S5 and Strategy S12 each had 10 correlations, making them the most influential. This shows that they are useful in solving many different challenges. On the other hand, Strategy S4 and Strategy S16 had only 4 correlations each, so they seemed less influential. The most significant challenges to the adoption of sustainable construction were identified as C6 and C8 which have 19 correlations, closely followed by C2 and C7 has 18 correlation each. This emphasises how crucial it is to address these key concerns using focused tactics. However, C5 had the fewest connections which has 10 correlations.

Providing sustainable construction training for construction workers and professionals is the most effective strategy. It has ten significant correlations and shows the strongest link with the factor of lack of training and skilled labour, with a correlation coefficient of 0.401. A shortage of skills and knowledge often causes inefficiency, material waste, and poor use of sustainable technologies. These problems reduce project performance and increase environmental impact (Naganarasimhulu and Tawalare, 2024). Training programmes give workers the technical skills and awareness needed to apply sustainable methods. This includes energy-efficient construction, responsible use of materials, and waste reduction (Mistri, Patel and Pitroda, 2019). Training also builds more than technical ability. It creates a culture of environmental responsibility and innovation. Skilled workers can adopt green technologies, avoid rework, and use advanced methods that cut carbon footprint and life cycle costs. Ongoing training in renewable energy, modular construction, and sustainable materials helps workers stay updated with global standards and climate goals (World Green Building Council, 2021).

Promoting sustainable construction in the private sector is also one of the most effective strategies. The factor of lack of knowledge on sustainable construction has the strongest correlation coefficient, with a value of 0.394, and there are ten significant correlations. Limited knowledge in the private sector often causes hesitation in adopting green practices. Many firms see them as costly, uncertain in benefits, and difficult to apply due to limited technical understanding (Abidin, 2010). This gap slows down market transformation, even though private developers and contractors play a key role in setting standards and driving demand for sustainable solutions. Haavik, Mlecnik and Rodsjo (2012); Bahho and Vale (2020) stated that raising awareness in the private sector through campaigns, demonstration projects, and incentive programmes helps close this gap. These efforts not only build knowledge but also show the economic and environmental value of green construction. When developers, contractors, and investors see benefits such as lower operating costs, healthier living spaces, and stronger brand reputation, they are more likely to invest in sustainable projects (Abidin, 2010).

For the factor of high initial cost, the most effective strategy is Environmental Impact Assessment (EIA), with a correlation coefficient of 0.441. The construction industry often perceives sustainable practices as financially burdensome due to the higher upfront costs of green materials, technologies, and certifications (Robichaud and Anantatmula, 2010). This cost barrier discourages developers and contractors, especially when short-term profit matters more than long-term value. Erdenekhuu, Kocsi and Mate (2022) stated that EIA can provide a structured framework to assess the environmental, social, and economic implications of construction activities before project implementation. It includes life-cycle costing and long-term savings in its analysis. This helps stakeholders see that higher initial spending may lead to lower operating costs, energy savings, and reduced maintenance over a building's lifespan (Ding, 2008). EIA can also point to design alternatives, resource efficiency, and material options that save money while meeting environmental goals (Erdenekhuu, Kocsi and Mate, 2022). Then, it is also a strategy for better decision-making. It reduces investor and developer uncertainty by showing both costs and benefits. In doing so, it lowers the perception of financial risk.

Lastly, with a correlation coefficient of 0.505, modular prefabrication is the most successful approach for the factor of resistance to change. Resistance to change is common in the construction industry. Many stakeholders prefer familiar methods and are reluctant to adopt new practices (Okoye and Odesola, 2020; Okoye et al., 2021; Lines, 2015). Their hesitation often comes from fear of unfamiliar processes, perceived risks, or doubts about the value of sustainable innovations. However, modular prefabrication helps solve this problem. It is a proven method that delivers clear benefits in quality, cost, and time. Prefabricated components are produced in controlled environments. This ensures consistency, reduces material waste, and shortens project timelines (Jiang et al., 2019). These advantages make it easier to convince stakeholders about the practical benefits of sustainable practices, which lowers resistance to change. Prefabrication also provides a visible example of how innovation can fit smoothly into existing systems (Gunawardena et al, 2014). It shows that sustainable approaches do not always add complexity. Instead, they can improve efficiency and reduce risks. In this way, modular prefabrication works as both a technical solution and a psychological enabler. It helps overcome cultural and organizational resistance, making the industry more open to sustainable construction (Jaillon and Poon, 2007).

Table 4.15: Correlation Between Challenges and Strategies for Adoption Sustainable Construction

Challenges / Strategies	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Total Sig.
S1	0.589**	0.249**	0.257**	0.195*	-	0.372**	0.273**	0.401**	-	-	7
S2	0.347**	0.549**	0.337**	0.234*	0.183*	0.328**	0.234*	0.361**	-	0.265**	9
S3	0.245**	0.403**	0.445**	0.245**	-	0.287**	0.327**	0.269**	0.230*	0.220*	9
S4	0.278**	0.261**	-	-	-	0.357**	-	0.238**	-	-	4
S5	0.378**	0.292**	0.245**	0.401**	0.391**	0.202*	0.291**	0.228*	0.206*	0.311**	10
S6	0.296**	0.363**	0.460**	-	-	0.422**	0.302**	0.284**	-	0.259**	7
S7	-	0.243**	-	0.198*	0.363**	-	0.248**	0.322**	0.290**	0.269**	7
S8	0.342**	-	0.186*	0.241**	-	0.270**	0.248**	0.369**	0.189*	0.228*	8
S9	0.464**	0.299**	0.255**	0.299**	0.263**	0.335**	0.413**	0.505**	-	0.304**	9
S10	0.205*	0.334**	0.339**	0.255**	-	0.408**	0.406**	0.256**	0.252**	0.251**	9
S11	-	0.293**	0.295**	0.207*	0.295**	0.219*	0.362**	-	-	0.388**	7
S12	0.194*	0.394**	0.347**	0.228*	0.236**	0.297**	0.308**	0.293**	0.183*	0.338**	10
S13	-	0.374**	-	0.224*	0.297**	0.209*	0.333**	0.195*	0.271**	0.321**	8
S14	0.293**	0.340**	0.289**	0.226*	-	0.393**	0.377**	0.353**	-	0.333**	8
S15	0.328**	0.316**	0.312**	0.240**	0.258**	0.336**	0.385**	0.412**	-	0.219*	9
S16	-	-	-	0.212*	-	0.278**	0.371**	0.418**	-	-	4
S17	-	0.286**	-	0.266**	0.261**	0.190*	0.298**	0.215*	0.370**	0.384**	8
S18	0.212*	0.333**	0.241**	0.247**	-	0.441**	0.499**	0.385**	0.229*	0.410**	9
S19	0.216*	0.242**	-	-	-	0.272**	-	0.271**	0.296**	-	5
S20	-	0.203*	-	0.282**	0.258**	0.308**	0.286**	0.327**	0.294**	0.295**	8
Total Sig.	14	18	13	17	10	19	18	19	11	16	

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

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

Note to Table 4.15:

C1- Weak policy enforcement, C2- Lack of knowledge on sustainable construction, C3- Low consumer awareness , C4- Lack of training and skilled labour, C5- Lack of professional capabilities or designers, C6- High initial cost, C7- Lack of financial incentives, C8- Resistance to change, C9- Sustainable materials supply chain limitation, C10- Long payback periods from sustainable practices.

S1- Increase incentives for sustainable construction, S2- Increase the awareness of sustainable construction for public, S3- Encouraging sustainable construction research, S4- Improve the regulations and policies of sustainable construction, S5- Provide sustainable construction training for construction workers and professional, S6- Building Information Modelling (BIM), S7- Improve rating tools and certificate system, S8- Enhancement of Green Building Codes, S9- Modular prefabrication, S10- Internet of Things (IoT), S11- Collaboration with outsiders, S12- Promoting sustainable construction in private sector, S13- Market creation for sustainable construction materials, S14- Smart Building, S15- Integrated Project Delivery Method, S16- Loan with low interest rate to Green Building, S17- Demonstration project and case studies, S18- Environmental Impact Assessment, S19- Consolidation of the role of Green Building Councils, S20- Establish more Green Building Associations.

4.12 Summary

Data collected from 120 professionals in the Malaysian construction industry, namely in the Klang Valley area, served as the basis for the study's conclusions. Professionals include consultants, contractors, and developers. The overall response rate to the survey was 36.5%. According to a reliability study, the gathered data showed good and exceptional internal consistency. A significant deviation from normality was observed in the SPSS analysis, which yielded a p-value of less than 0.001 for the benefits, challenges, and strategies for adopting sustainable construction. From the descriptive analysis, the most significant benefits of sustainable construction were identified as improvements in health, reduction of carbon footprint, and waste reduction.

On the other hand, the most pressing challenges identified were high initial costs, inadequate policy enforcement, and low consumer awareness. To overcome these barriers, respondents highlighted several effective strategies, most notably increasing incentives for sustainable construction, improving policies and regulations, and loans with low interest rates for green building.

The Kruskal-Wallis test provided further insights into stakeholder differences. Most of the benefits and barriers were viewed similarly by all groups. However, water efficiency was seen differently. Consultants and contractors put it in the top three benefits, while developers put it much lower. Similar differences were observed in strategies such as enhancing policies and regulations, which developers and contractors ranked highly, whereas consultants preferred to focus on working with outside partners. Moreover, results from the Spearman's correlation test demonstrated significant relationships between challenges and strategies. This study indicates that the variables demonstrate a weak to moderate correlation. Lastly, the factor analysis effectively uncovered four key underlying factors from the 20 strategies for adopting sustainable construction within Malaysia's construction industry.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary and conclusion of the research study by presenting a synthesis of the most important aspects that were discovered during the research. This chapter presents a discussion of the research implications, aiming to highlight the significance of the findings for stakeholders and future research. Aside from that, this chapter contains an introduction to the limits, as well as recommendations for future research that are comparable to the one being discussed.

5.2 Conclusion

The construction industry is widely considered one of the largest contributors to environmental problems. This is because the construction industry is associated with excessive energy use, high carbon emissions, resource depletion, and waste generation. In Malaysia, these impacts have raised serious concerns about the industry's sustainability and its contribution to climate change and environmental degradation. Sustainable construction has the potential to solve these problems. However, its adoption is still limited due to challenges such as high initial costs, lack of knowledge, weak enforcement of policies, and resistance to change. Therefore, the purpose of this study was to examine the benefits, challenges, and strategies for advancing sustainable construction in Malaysia.

The aim of this research is to explore the benefits of sustainable construction in Malaysia's construction industry, with the goal of offering practical solutions to the existing issues. To effectively achieve the objective, three objectives were established beforehand. The three research objectives constructed in this study are: (1) To identify the benefits of sustainable construction in Malaysia's construction industry; (2) To investigate the challenges of sustainable construction in Malaysia's construction industry; and (3) To appraise the strategies for adopting sustainable construction in Malaysia's construction industry. A detailed literature review was conducted before the primary study. The literature research identified 10 benefits of sustainable construction, 10 barriers to sustainable construction, and 20 strategies for adopting sustainable construction from publications across different countries. A structured survey was subsequently conducted in the Klang Valley region to collect data from construction stakeholders. A well-structured, closed-ended questionnaire was utilised as the major study tool to enable efficient data collection. The poll focused on construction professionals from three primary categories: developers, consultants, and contractors. A total of 120 sets of valid responses were collected successfully. Before conducting a detailed statistical analysis, reliability and normality tests were performed to assess the internal consistency and distribution characteristics of the data. The initial tests validated the dataset's appropriateness for subsequent investigation. In conclusion, all objectives outlined at the outset of the study have been achieved and are listed below:

Objective 1:

The first objective of this research is to identify the benefits of sustainable construction in Malaysia’s construction industry. To determine the respondents' level of agreement with the application of sustainable construction benefits in the construction industry, a range of options were presented to them. The results indicated that the five most important benefits were as follows: (1) health improvement; (2) reduce carbon footprint; (3) waste reduction; (4) water efficiency; and (5) lifecycle cost reduction. Furthermore, this study showed that respondents' opinions on five advantages applied in Malaysian construction projects varied. Contractor rated water efficiency and lifecycle cost reduction slightly higher than developer and consultant.

Objective 2:

The second objective of this research is to investigate the challenges of sustainable construction in Malaysia’s construction industry. The responders must express their degree of agreement with the 10 barriers of sustainable construction in the Malaysian construction industry. As a result, the five most significant challenges are revealed as: (1) high initial cost; (2) weak policy enforcement; (3) low consumer awareness; (4) lack of financial incentives; (5) lack of training and skilled labour. Moreover, it was shown that respondents' perceptions differed significantly among the subsequent challenges: lack of financial incentives ,and lack of training and skilled labour.

Next, the Spearman Correlation Test was utilised to assess the relationship between the challenges of sustainable construction and the strategies for adopting sustainable construction in Malaysia’s construction industry. It is shown that the variables “ Weak Policy Enforcement” (C1) and “Increase Incentives for Sustainable Construction” (S1) had the strongest correlation, with a coefficient of 0.589. The challenges that have shown the highest correlation counts of 19 are “High Initial Cost” (C6) and “Resistance to Change” (C8).

Objective 3:

The third objective of this study was to evaluate strategies for adopting sustainable construction in the Malaysian construction industry. To achieve this, factor analysis was applied to 20 identified strategies, which resulted in the extraction of five key underlying factors: Capacity Building and Innovation, Innovative Financing and Smart Delivery Approaches, Institutional and Organisational Support, Policy and Environmental Governance, and Collaboration and Market Development.

Among the five, Capacity Building and Innovation and Innovative Financing and Smart Delivery Approaches consistently emerged as the most influential underlying factors which the total variance is 13.904% and 13.155%. This outcome highlights the industry’s recognition that the successful adoption of sustainable construction requires not only financial mechanisms but also skilled human capital and innovative technologies.

5.3 Research Implications

This research makes important contributions to the Malaysian construction industry and the wider sustainability field. It examines the benefits, barriers, and strategies for adopting sustainable construction. The study gives a clearer picture of how the sector is moving toward greener practices. The results show that sustainable construction brings key benefits such as reducing carbon emissions, improving public health, and using resources more efficiently. At the same time, it faces major challenges. These include high costs, lack of knowledge, and resistance to change. These findings point to areas where support and intervention are most needed. The study also highlights strategies that can speed up adoption. Factor analysis identified five main underlying factors: Capacity Building and Innovation, Innovative Financing and Smart Delivery Approaches, Institutional and Organisational Support, Policy and Environmental Governance, and Collaboration and Market Development. These factors stress the need for training, better funding options, stronger regulations, and more cooperation across stakeholders. Together, they offer a roadmap for scaling up sustainable practices.

From a policy perspective, the findings provide valuable input for government agencies and regulators. Policymakers can use the identified factors to design more targeted sustainability policies, tax incentives, and grant schemes that address the real barriers faced by industry players. Strengthening policy enforcement, improving green certification systems, and integrating sustainability criteria into public procurement can further drive industry transformation.

Moreover, from an academic and institutional perspective, this study contributes to the growing body of knowledge on sustainable construction in developing economies. It highlights the importance of incorporating sustainability principles, green technologies, and innovation management into the curriculum of construction related programmes. Higher education institutions can also use the results to develop training modules and industry university research partnerships that enhance practitioners' competence.

The research also adds a global perspective. It compares Malaysia's situation with other countries. The results show that capacity building, good governance, and collaboration are common enablers everywhere. However, financing options and knowledge-sharing platforms are less developed in many developing countries. This comparison shows that the findings are relevant not only to Malaysia but also to other regions working on sustainability. The study has practical implications for industry players, policymakers, and decision-makers. It provides evidence-based guidance for integrating sustainability into mainstream construction. This includes incentives, training, innovation, and closer cooperation between government and industry. Aligning policies with market needs and new technologies will help the industry grow in a sustainable way. In conclusion, the study closes the gap between theory and practice. It offers a framework to guide the construction industry toward a greener and more sustainable future.

5.4 Research Limitations

The findings of this research are subject to several limitations that must be acknowledged to properly frame the scope of the results. Firstly, the study primarily concentrates on identifying the benefits, challenges, and strategies linked to the adoption of sustainable construction within the Malaysian construction industry. While this focus offers valuable insights into the key factors that shape adoption, it does not fully address the actual outcomes or practical implementation issues that may emerge once strategies are applied in real projects. Sustainable construction involves long-term operations, changing market conditions, and policy enforcement. Since this study only focuses on perceptions and correlations, it cannot show how challenges and strategies work in different project stages or over time. Future research should include case studies and long-term analysis to see how sustainable practices are applied, monitored, and improved in real projects.

Second, the research uses a quantitative method with structured questionnaires and Likert-scale responses to gather data from stakeholders. This method is good for finding patterns and correlations, but it limits the depth of the results. Perceptions and experiences are personal, and close-ended answers may not capture the full details or variations of these views. Without qualitative methods like interviews or focus groups, the study misses the chance to explore the reasoning, motivations, and real experiences of participants in more detail.

Third, the study mainly collected responses from Klang Valley and selected urban areas. This may limit how far the findings can be applied. Construction practices, resources, and enforcement in rural areas or smaller states may be very different from those in urban hubs. As a result, the findings may not fully reflect the situation across the whole country. In addition, the study focuses on developers, contractors, and consultants as the main stakeholders. These groups are important in delivering projects, but other actors such as suppliers, regulators, and end-users were not included. Their perspectives could provide valuable insights, especially on supply chain readiness, government enforcement, and public acceptance of sustainable construction.

Finally, the study captures perceptions at one point in time. It does not reflect changes in attitudes, policies, or market trends that may happen in the future. As awareness of sustainability grows and new technologies emerge, views and practices in the industry are likely to change. Future research should use a long-term approach to track these changes and see how they affect the adoption of sustainable construction.

5.5 Recommendations

Future studies should consider addressing several limitations identified in this research. First, this study relied primarily on a quantitative approach using Likert-scale questionnaires. While this method is useful for identifying patterns and correlations, it may not fully capture the underlying perceptions, motivations, and lived experiences of industry stakeholders. To overcome this limitation, future research should adopt a mixed-methods design, combining surveys with qualitative techniques such as semi-structured interviews, workshops, or focus groups. Such an approach would allow researchers to uncover deeper insights into the rationale behind stakeholder responses, while also providing richer contextual understanding of the factors shaping sustainable construction adoption in practice.

Secondly, this study was conducted mainly within the Klang Valley. It is Malaysia’s most advanced and economically developed construction hub. While this focus provided a practical advantage in accessing respondents, it may restrict the generalisability of findings to other regions. Future research should broaden its geographical scope to include states across Peninsular Malaysia as well as Sabah and Sarawak to strengthen external validity. These areas may demonstrate variations in economic growth, infrastructure readiness, regulatory enforcement, and sustainability awareness, all of which could influence stakeholder perceptions. Comparative studies with other developing countries would also provide meaningful cross-regional perspectives, highlighting both common challenges and context-specific solutions.

Thirdly, while this study focused on developers, consultants, and contractors, future studies should broaden the scope to include suppliers, policymakers, regulators, and end-users. These groups play a crucial role in shaping sustainable construction practices, especially in terms of supply chain capacity, regulatory enforcement, and consumer demand. Including these stakeholders would help to generate a more holistic perspective on the barriers and drivers of sustainable construction adoption.

Last but not least, future research should consider employing larger sample sizes and exploring probability sampling methods to minimise sampling bias and enhance the validity of findings. Researchers should also diversify survey distribution platforms, combining online methods with walk-in distribution, industry associations, and professional networks to capture a more representative sample.

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APPENDICES

Appendix A: Questionnaire

INVESTIGATING SUSTAINABLE CONSTRUCTION: BENEFITS, CHALLENGES AND STRATEGIES

Dear Sir / Madam,

I am Tung Liz Quay, a final-year student from the Bachelor of Science (Honours) Quantity Surveying programme at Universiti Tunku Abdul Rahman (UTAR). I am currently conducting research for my final year project titled "Investigating Sustainable Construction: Benefits, Challenges and Strategies."

Sustainable construction refers to the practice of designing, building, and operating structures in a way that minimises negative environmental impacts, conserves natural resources, and supports the health and well-being of people.

This questionnaire is designed to gather insights from professionals and individuals involved in the construction industry regarding sustainable construction practices. Your valuable responses will contribute significantly to the findings of this research.

The questionnaire consists of **four (4) sections** and will take approximately **10 minutes** to complete. All responses will be kept confidential and used solely for academic purposes.

If you have any questions or encounter any issues while completing the questionnaire, please feel free to contact me at *lizquay12@1utar.my*.

Thank you for your time and participation.

* Indicates required question

Section A: Demographic Information

Please provide the following background information. Your responses will be kept strictly confidential and used for research purposes only.

1. 1. The nature of your current organisation in the construction industry. *

Mark only one oval.

- Developer / Client
- Consultant
- Contractor

2. 2. What is your highest education level? *

Mark only one oval.

- High School
- Diploma
- Degree
- Postgraduate (PhD, Master)

3. 3. 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

4. 4. What is your position in the company? *

Mark only one oval.

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

5. 6. To what extent do you agree that implementing sustainable construction practices positively impacts environmental, economic, and social aspects of the construction industry? *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

6. 7. To what extent do you agree that unresolved barriers in sustainable construction discourage public support for green building initiatives in Malaysia? *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

7. 8. How likely do you think the Malaysian construction industry is to adopt sustainable construction practices on a wide scale in the near future? *

Mark only one oval.

- Very Unlikely
- Unlikely
- Neutral
- Likely
- Very Likely

Section B: Benefits of Sustainable Construction in Malaysia's Construction Industry

This section aims to gather your views on the potential benefits of sustainable construction practices in Malaysia.

Please indicate the extent to which you agree with each of the following statements.

8. **Environmental Benefits** *

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Reduce carbon footprint	⬭	⬭	⬭	⬭	⬭
Energy efficiency	⬭	⬭	⬭	⬭	⬭
Waste reduction	⬭	⬭	⬭	⬭	⬭
Water efficiency	⬭	⬭	⬭	⬭	⬭
Better use of materials	⬭	⬭	⬭	⬭	⬭

9. **Social Benefits** *

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Health improvement	⬭	⬭	⬭	⬭	⬭
Increased productivity, staff recruitment and retention	⬭	⬭	⬭	⬭	⬭
Enhance comfort condition inside the building	⬭	⬭	⬭	⬭	⬭

10. **Economic Benefits** *

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Lifecycle cost reduction	⬭	⬭	⬭	⬭	⬭
Increase the property value	⬭	⬭	⬭	⬭	⬭

Section C: Challenges of Sustainable Construction in Malaysia's Construction Industry

This section aims to understand the key challenges faced in implementing sustainable construction in Malaysia.

Please indicate the extent to which you agree with each of the following statements.

11. *

Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Weak policy enforcement	⬭	⬭	⬭	⬭	⬭
Lack of knowledge on sustainable construction	⬭	⬭	⬭	⬭	⬭
Low consumer awareness	⬭	⬭	⬭	⬭	⬭
Lack of training and skilled labour	⬭	⬭	⬭	⬭	⬭
Lack of professional capabilities or designers	⬭	⬭	⬭	⬭	⬭
High initial cost	⬭	⬭	⬭	⬭	⬭
Lack of financial incentives	⬭	⬭	⬭	⬭	⬭
Resistance to change	⬭	⬭	⬭	⬭	⬭
Sustainable materials supply chain limitation	⬭	⬭	⬭	⬭	⬭
Long payback periods from sustainable practices	⬭	⬭	⬭	⬭	⬭

Section D: Strategies for Adopting Sustainable Construction in Malaysia's Construction Industry

This section aims to assess your opinion on how much each of the following strategies contributes to supporting the adoption of sustainable construction in Malaysia's construction industry.

Please indicate the extent to which you believe each strategy contributes

12. *

Mark only one oval per row.

	Not at All	Slightly	Moderately	Significantly	Very Significantly
Increase incentives for sustainable construction	⬭	⬭	⬭	⬭	⬭
Increase the awareness of sustainable construction for public	⬭	⬭	⬭	⬭	⬭
Encouraging sustainable construction research	⬭	⬭	⬭	⬭	⬭
Improve the regulations and policies of sustainable construction	⬭	⬭	⬭	⬭	⬭
Provide sustainable construction training for construction workers and professional	⬭	⬭	⬭	⬭	⬭
Building Information Modelling (BIM)	⬭	⬭	⬭	⬭	⬭
Improve rating tools and certificate system	⬭	⬭	⬭	⬭	⬭
Enhancement of Green Building Codes	⬭	⬭	⬭	⬭	⬭
Modular prefabrication	⬭	⬭	⬭	⬭	⬭
Internet of Things (IoT)	⬭	⬭	⬭	⬭	⬭
Collaboration with outsiders	⬭	⬭	⬭	⬭	⬭
Promoting sustainable construction in private sector	⬭	⬭	⬭	⬭	⬭
Market creation for sustainable construction materials	⬭	⬭	⬭	⬭	⬭
Smart Building	⬭	⬭	⬭	⬭	⬭

Integrated Project Delivery Method					
Loan with low interest rate to Green Building					
Demonstration project and case studies					
Environmental Impact Assessment					
Consolidation of the role of Green Building Councils					
Establish more Green Building Associations					