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The Implementation of Sustainability Practices in Construction Site and its Effectiveness in Klang Valley

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Abstract
Awareness of sustainable and green practices in Malaysia's construction industry remains suboptimal. One key factor influencing the implementation of these practices is the level of awareness among contractors, despite government incentives aimed at mitigating the social, environmental, and economic impacts without hindering industry growth. Aligning construction growth with sustainable practices is crucial to safeguarding the future of the next generation. Notably, approximately 24% of Malaysia's carbon dioxide emissions originate from the construction sector, underscoring the importance of sustainable construction. This paper aims to analyse the factors affecting the implementation of sustainable practices on construction sites and assess their effectiveness. Data were collected through 368 questionnaires distributed among contractors in the Klang Valley region and analysed using the Relative Importance Index (RII) and Effectiveness Index (EI) methods with SPSS software. The study considered social, environmental, and economic factors influencing sustainable implementation. The findings indicate that all identified factors are deemed extremely important in influencing sustainable practices on construction sites. This research highlights the reasons behind contractors' reluctance to adopt sustainable practices in Klang Valley, providing insights for the government to improve strategies that encourage the adoption of sustainability in construction.
Keywords: Sustainable Practices, Construction Industry, Implementation, Klang Valley, Relative Importance Index (Rii).

Introduction

Sustainable construction encompasses three critical aspects: social, economic, and environmental considerations (Mahfuth et al., 2018). In the construction industry, the sustainability of project delivery can significantly impact both social and environmental dimensions. For infrastructure projects, sustainable project management is essential, as it brings about lasting changes in the community and involves multiple stakeholders with diverse expectations (Hirpara et al., 2018).

Data published by the United Nations Environment Programme (UNEP) revealed that the building sector was responsible for 34% of global energy demand and 37% of energy and process-related carbon dioxide (CO_2) emissions in 2021 (UNEP, 2024). Despite this, the investments driven by property development and the growing demand for global business have led to an increase in construction activities. The rising demand for infrastructure and leisure facilities has rapidly altered landforms, depleting natural resources at a faster rate than they can be replenished, thus underscoring the need for sustainable development (Lam et al., 2009).

As urbanization and structural growth continue to meet the needs of the population, the demand from construction stakeholders for ecologically sustainable practices is pushing construction firms to adopt social sustainability measures in their projects (Bamgbade et al., 2017). However, a lack of knowledge is indeed a significant barrier to the adoption of sustainable procurement in the construction industry (Ojo & Gbadegesin, (2023) Hwang et al 2018).

Several factors influence the effectiveness of contractors in implementing sustainability practices on construction sites, whether they are from private or government organizations. According to Abidin et al (2020), despite some successful initiatives, these efforts have been insufficient. There is evidence of a lack of self-motivation among local construction contractors to apply sustainability concepts effectively.

Only a few countries have fully implemented sustainable performance (SP) within construction organizations. This indicates a gap in current practices related to sustainability, highlighting the need to establish and enhance the implementation of sustainable practices. This study aims to analyse the factors contributing to the implementation of sustainability and evaluate their effectiveness on construction sites, with the goal of improving work quality while maintaining social, environmental, and economic sustainability. Additionally, the study seeks to assess the current perceptions of contractors from both private and government sectors regarding sustainability in the construction process. Each aspect—social, environmental, and economic—has its own set of factors that influence sustainable implementation in construction.

This research aims to promote environmental protection while also benefiting social well-being by focusing on the welfare of workers and the advantages for the community or end-users. Economic prosperity can also be enhanced through cost efficiency, compliance with legislation, and improved business reputation. The findings will shed light on the factors that contribute to the effectiveness of sustainable practices and the constraints from the contractor's perspective that hinder the adoption of sustainability in construction sites, thereby enabling informed actions to drive change in the industry.

Sustainable Development

The construction industry has been identified as a major contributor to environmental degradation and pollution (Ding, 2008). Urban development has prompted an urgent need for creating and developing sustainable buildings. Sustainable buildings, also known as "green buildings," are designed to be energy-efficient, conserve water, use recyclable materials, and incorporate non-toxic features. These characteristics contribute to environmental, social, and economic sustainability (Ali & Al Nsairat, 2009).

The concept of sustainable development is closely related to the triple bottom line of sustainability, which includes social, environmental, and economic aspects. This triple bottom line is also known as the main principle in sustainability practices, where each aspect is interrelated, forming a balanced approach to sustainability (Abidin, 2010). Social development is a crucial component of achieving sustainable development. Its objective is to meet human needs without compromising the environment for future generations. Social development not only enhances local autonomy but also ensures the security and accountability of stakeholders and practitioners in construction (Valunjkar, 2020).

Ecological development in current construction projects must also be considered seriously, as these projects impact the use of natural resources. With increasing urbanization, the demand for construction has risen, leading some practitioners to overlook the environmental impact in favour of speeding up projects (Phoya, 2018). It is essential for key players in construction to maintain current resources and ecological systems to avoid jeopardizing the future. Ecological development focuses not only on reducing waste but also on preserving resources and the built environment's ecological systems (Abidin, 2010).

Balanced sustainability encompasses not only environmental and social aspects, but also economic sectors impacted by the construction process. Sustainable development benefits contractors, developers, real estate, and business owners in the construction industry due to high demand and the need for more sustainable or "green" buildings from both government and private sectors. Numerous incentives have been provided by the government to support sustainable practices on construction sites (Bahaudin et al., 2017). As Malaysia moves towards sustainable development, sustainable buildings will remain profitable and can expand the market.

The relationship between social and economic development forms socio-economic sustainability. Socio-economic development, also known as socioeconomic development, addresses public concerns in developing social policies and economic initiatives. It is a progressive reinforcement of an organization's qualitative and quantitative dimensions towards higher efficiency, well-being, justice, and democracy at all levels (Hirpara & Kashiyani, 2018). On the other hand, a puristic green approach emerges from the relationship between social and environmental aspects. Understanding social needs concerning environmental impact can lead to more sustainable or green construction. Conservation can also be achieved by understanding the economic and ecological development aspects (Abidin et al., 2020). The combination of these two aspects will maintain the sustainability of natural resources while meeting the demand for construction.

In conclusion, a true understanding of the importance of each aspect and their interrelation can form balanced sustainability in sustainable development. Each aspect is crucial as they are the key principles to achieving a well-rounded sustainable building in construction.

Implementation of Sustainable Construction

Sustainability is an economic state where the demands placed on the environment by people and commerce can be met without compromising the environment's ability to provide for future generations (Hawken, 1995). In the context of construction, sustainability involves developing designs that balance a project's short-term objectives with long-term goals of efficient operating systems that protect the environment and natural resources (Levy, 2017).

To meet the social need for shelter, the economic need for investment, and corporate objectives, buildings and structures were developed. However, satisfying these needs often comes at a high price, causing irreversible damage to the environment (Abidin, 2009). The Brundtland Report (1987), introduced the concept of sustainable development as a solution to this issue. Since then, numerous significant global events have raised awareness about environmental and sustainability agendas, including the Rio Earth Summit (1992), the Maastricht Treaty (1992), the Kyoto Conference on Global Warming (1997), the Johannesburg Earth Summit (2002), and the Washington Earth Observation Summit (2003), (Zainul Abidin, 2005). These events have encouraged many countries to adopt sustainable practices within their industries. A key aspect of sustainable construction is the responsibility of the construction industry to achieve sustainability (Abidin, 2009).

The benefits of sustainable building projects have made construction practitioners worldwide more appreciative of sustainability. Research by Hydes and Creech (2000), demonstrated that green building concepts are more cost-effective than conventional methods and save energy. This is further supported by Heerwagen (2000), Barlett and Howard (2000), and Pettifer (2004), who noted that sustainable buildings can lead to better quality of life, increased work efficiency, and healthier work environments. Businesses also benefit from sustainability practices, as highlighted by Yates (2001), who found that these practices offer diverse and significant advantages.

In conclusion, the path towards sustainable construction enables practitioners in the construction industry to be more responsible for environmental protection while also addressing social and economic needs, ultimately aiming for a better quality of life.

Factors Affecting Sustainable Construction

According to Brundtland (1987), sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable construction encompasses three crucial aspects: social, economic, and environmental, all of which must be considered (Mahfuth et al., 2018). Each aspect has its own set of factors that influence the implementation of sustainability in the construction process.

Economic sustainability involves increasing profitability by making more efficient use of resources, including labor, materials, water, and energy. This aspect of sustainability includes approaches such as considering life-cycle costs, internalizing external costs, exploring alternative financing mechanisms, developing appropriate economic instruments to promote sustainable consumption, and considering the economic impact on local structures (Hussin et al., 2013). Failure to implement sustainable practices can lead to time overruns, cost overruns, excessive construction waste, resource consumption, and environmental threats at construction sites. According to research by Zhong and Wu (2015), factors such as structural costs, maintenance costs, financial costs, non-construction costs, disposal and demolition costs, and increased construction area significantly affect economic sustainability practices at construction sites. This research study includes these factors to analyze their relative importance in implementing sustainability at construction sites in Klang Valley.

According to Almahmoud and Doloi (2020), social sustainability in the urban environment has two dimensions: social equality and community sustainability. Social equality emphasizes equal employment opportunities and access to services, while community sustainability focuses on social interaction, cohesion, and social capital. Kumar et al (1993), stated that social equality is part of the political dimension, involving equal participation in decision-making, equal distribution of resources, human rights, gender equality, cultural diversity, and ethical systems. Larsen (2009), supported this by identifying social equality as the core of social sustainability. Several researchers agree that social sustainability in construction projects includes creating job opportunities, providing investment opportunities, enhancing safety and security, preserving the natural environment of the project location, and enhancing construction knowledge (Hammer, 2009; Ma, 2011; Macfarlane and Cook, 2002; Talukhaba et al., 2005). These components are connected to basic human rights, ensuring a minimum acceptable level of well-being in the community.

Ahn et al (2010), noted that a significant share of our society's environmental impact comes from the built environment, including transportation and industrial processes, which account for approximately 40% of total energy use. As economies flourish, the need for infrastructure and facilities increases, putting more pressure on natural resources and severely impacting the environment and living organisms. The main challenge for the industry is to reduce the environmental impacts of these activities. Kaatz et al. (2005) confirmed that construction activities have detrimental environmental effects, including energy consumption, dust and gas emissions, waste generation, noise pollution, water discharge, water resource misuse, land misuse and pollution, and the consumption of non-renewable natural resources. According to Amiril et al. (2014), factors affecting environmental sustainability include land use or site selection, water quality, air quality, noise quality, ecology and biodiversity, visual impact, waste management, and energy and carbon emissions, pollution control, erosion and sediment control and flora and fauna.

Methodology

In this study, a questionnaire survey was conducted to gather participants' opinions on the research topic. The choice of methodology takes consideration based on the limitation of the study which is cost and time constraint. The time availability of the study to gain the information is short as it only takes less than three month for the researcher to gather it. Besides that, cost of transportation also limited as this research is not funded.

The questionnaire, a widely used method for data collection in descriptive analysis, was employed to assess 55 factors divided into sub-criteria of key sustainable principles that influence the implementation of sustainability practices on construction sites. These factors were identified through a comprehensive literature review. A Likert scale method was used to rate respondents' opinions on the factors contributing to the implementation of sustainable practices at construction sites. The data collected on these factors will help identify the main influences on the adoption of sustainability practices and analyze their effectiveness in promoting sustainability at construction sites.

The sampling method for this study was finalized as snowball sampling. This method involves using primary data sources to recommend other potential participants, helping to increase the number of respondents and achieve the desired sample size. Snowball sampling was chosen for this research due to the difficulty in directly contacting upper-level management among construction practitioners. Additionally, this method enhances the efficiency of data collection by reducing the time required to gather the necessary information.

To target the desired participants, data on the number of contractors from all classes working in the Klang Valley area was obtained from current CIDB databases. In the final stage of this research, the sample size was determined using the Krejcie and Morgan (1970) table formula, ensuring that an appropriate number of respondents was included in the study. A total of 368 set of questionnaires were required for this study.

The raw data collected from the questionnaires were sorted, tabulated, and analysed using the Relative Importance Index (RII) and Effectiveness Index (EI) formulas. The RII using formula in Equation 1 was adopted to rank the factors from the most important to the least important factor of the study.

$$RII = \frac{\sum W}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N} \quad \text{(Equation 1)}$$

Where W is a loading given for every factor by the respondent, between 1 to 5, (n_1= not at all important n_2 = low important, n_3 = neutral, n_4 = very important, n_5 = extremely important). A is the first load (i.e. 5 in the study) and N is the total number of respondents. The RII value ranges from 0 to 1. The analyzed data was ultimately presented using descriptive methods to facilitate easy interpretation and enable comparisons. Table 1 shows the RII level of important interpretation based on the RII value that had been calculated using the formula from Equation 1. The RII value, ranging from 0 to 1.0, indicates the importance of various factors based on the principal criteria of sustainable implementation, including economic, social, and environmental aspects.

Table 1
Relative Importance Index (RII) Value Interpretation

RII Value	RII Level of Important
0 - 0.19	Not all important
0.20 – 0.39	Low important
0.49 – 0.59	Neutral
0.60 – 0.79	Very important
0.80 – 1.0	Extremely important

Next, to evaluate the effectiveness of the factors influencing sustainability practices at construction sites, the Effectiveness Index (EI) analysis was used. Goodman (1980) developed the basic formula for calculating EI, as shown in Equation 2. The EI was computed by dividing the pretest-to-posttest change by the maximum possible increase if raw scores are used.

$$EI = \frac{P_2 - P_1}{P_0 - P_1} \quad \text{(Equation 2)}$$

Where P_0 is the maximum possible score, which is 100, P_1 is the pretest score and P_2 is the posttest score of the data collection. The pretest score of this research is being ignored. Table 2 shows the effectiveness level of important interpretation based on the effectiveness percentage value that had been calculated using the formula from Equation 2. The effectiveness percentage, ranging from 0 to 100, indicates the importance of various factors that influence the implementation of sustainable practices on construction sites. These factors are evaluated based on the core criteria of sustainability: economic, social, and environmental considerations.

Table 2
Effectiveness Percentage Interpretation

Effectiveness Percentage (%)	Effectiveness Level
0 - 19	Not all important
20 – 39	Low important
49 – 59	Neutral
60 – 79	Very important
80 – 100	Extremely important

Results and Discussion

Figure 1 illustrates the composition of the respondents in this study, which consists of 227 contractors from all classes, ranging from G1 to G7. The majority of respondents are from the G7 class, representing 30% of the total data collected. The second largest group is from the G4 class (17%), followed by G3 (14%), G5 (13%), G6 (11%), G1 (8%), and G2 (7%). Despite the varied classes, all respondents were deemed qualified and technically fit for the study's requirements. No specific contractor class was singled out for analysis, as opinions from all groups were considered valid for research purposes. The response rate for this study was 62%, which is adequate given that Akintoye (2000) and Dulaimi et al. (2003) state that the typical survey response rate in the construction industry ranges from 20% to 30%.

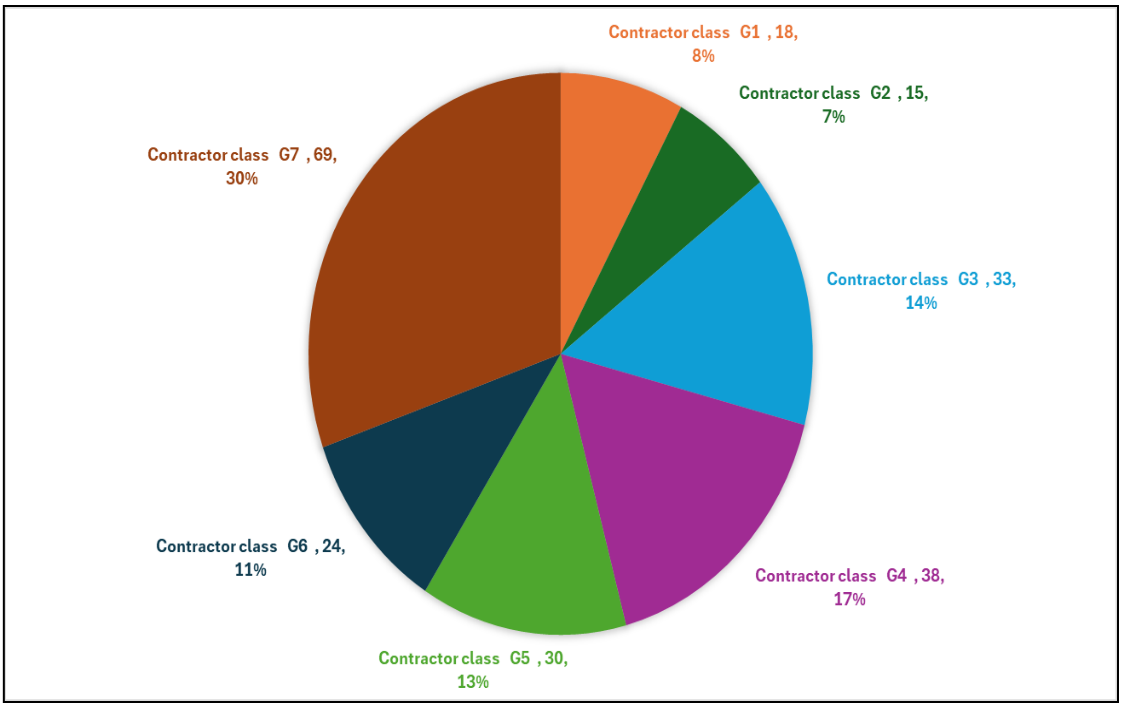

Figure 1. Contractors' Class

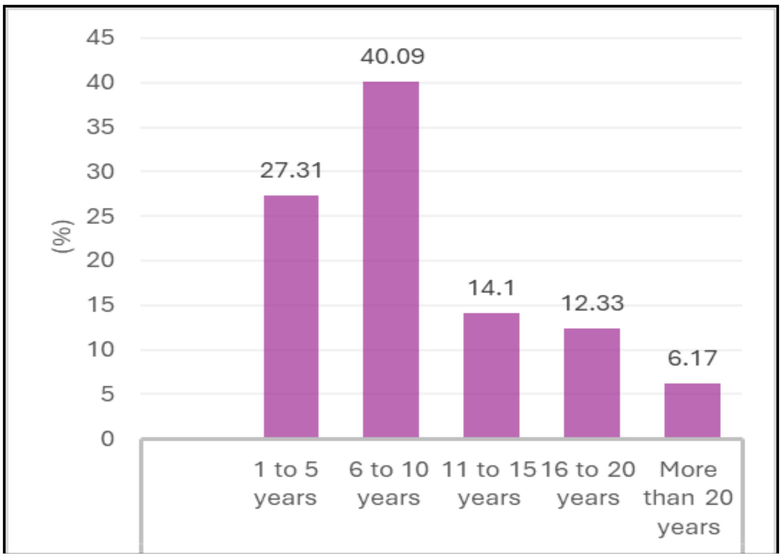

Figure 2. Company Years of Operation

Figure 2 shows that most contractor companies have been in operation for more than 5 years, with 40% having operated for 6 to 10 years. This indicates that nearly half of the construction companies involved in this research have substantial experience on construction sites. In this context, the length of working experience is likely to influence an individual's knowledge within the organization and their area of authority. Longer work experience, such as 6 to 10 years or more, allows individuals to gain more exposure, ultimately broadening their knowledge related to this study. This is a good indication of their ability to provide more convincing feedback for the current study.

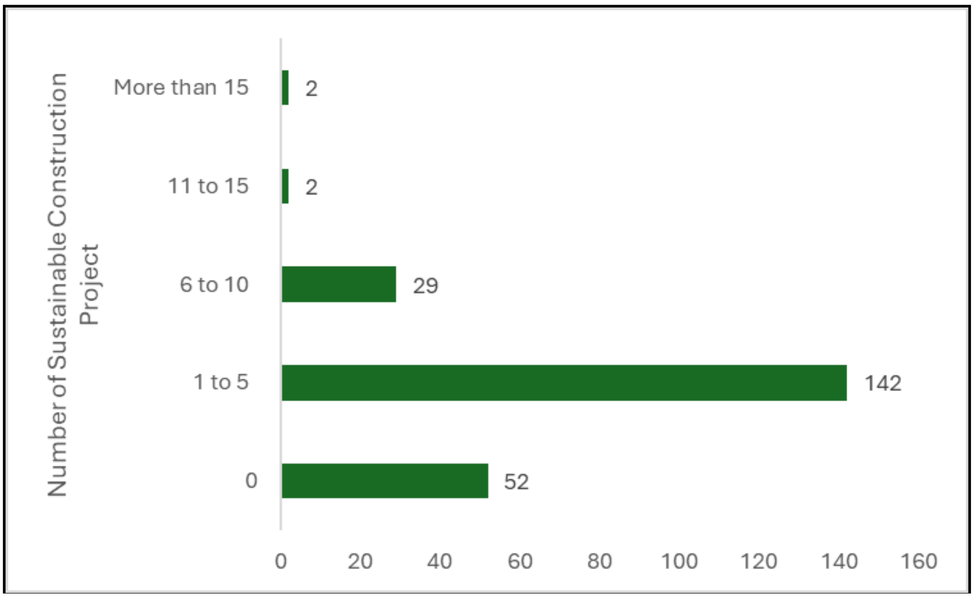

Figure 3. Number of Sustainable Construction Projects Involved

Figure 3 represents the number of previous sustainable construction projects completed by the construction companies. It was found that 23% of the respondents had been involved in 1 to 5 sustainable development projects, while 13% had participated in 6 to 10 such projects. Additionally, a few contractors have been involved in more than 10 sustainable projects over the years. This pool of respondents is therefore well-qualified to provide informed opinions on the implementation of sustainable practices on construction sites. Although the number of sustainable projects each contractor has been involved in may be small, they still possess a basic understanding of sustainable practices in construction, which aligns with the purpose of this research study.

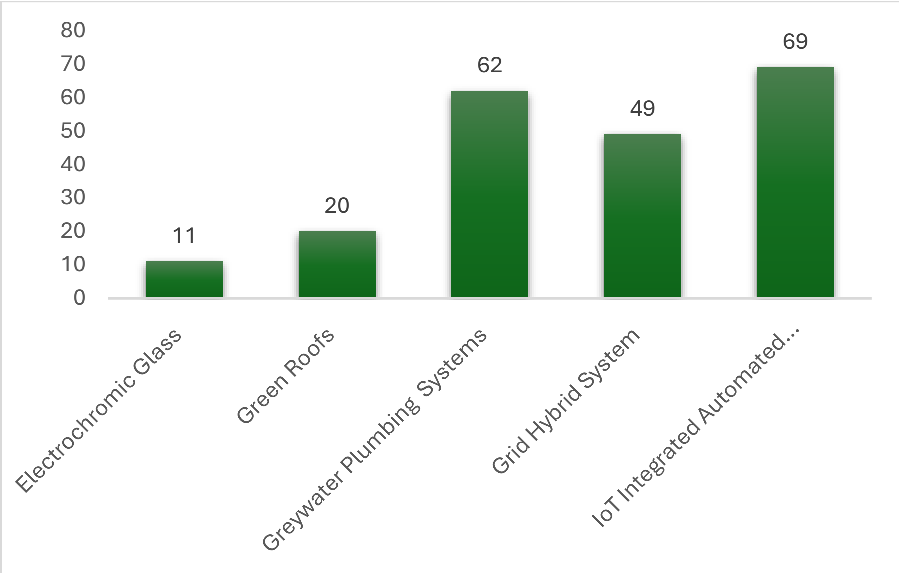

Figure 4. Types of Sustainable Construction That Have Been Used in The Projects

Figure 4 illustrates the types of sustainable construction practices implemented by the contractor's company. Most respondents (28%) selected self-healing concrete as their preferred sustainable construction method. According to Huseien et al (2019), self-healing concrete offers numerous advantages, particularly in terms of durability. It is especially beneficial in environments where human intervention is challenging, such as harsh physical and chemical conditions. Following self-healing concrete, 20% of respondents chose Internet of Things (IoT) Integrated Automated Building Systems. It is now feasible to use database management software, such as Building Information Modeling (BIM) environments, cloud computing, and web-based energy concepts, to implement IoT-BIMs in the PC building construction industry. These technologies monitor indoor environmental conditions and enhance user comfort during the building management process. Many construction companies worldwide are adopting IoT systems due to their benefits, including sensing, recognition, and positioning technologies. These systems facilitate effective control of health, safety, security, and efficiency in existing smart buildings and occupant tracking systems, increasing contractors' interest in this type of sustainable construction (Ismail, 2022).

In this study, the analysis of the Relative Importance Index and Effectiveness Index percentage is divided into two parts: sub-factors for each sustainable criterion and overall principal criteria. The mean and standard deviation of the factors, referred to as "items" in this research, were used to measure the dispersion of the data in relation to the mean value.

Table 3
Relative Importance Index (RII) and Effectiveness Index (EI) Percentage of Economic Factors

Economic Factors	Mean	Standard Deviation	RII Value	EI (%)	Ranking
Water cost	4.51	0.627	0.90	90.20	1
Durability	4.50	0.605	0.90	90.00	2
Material costs	4.46	0.597	0.89	89.20	3
Land cost	4.45	0.632	0.89	89.00	4
Lead-times for the required tasks and activities	4.45	0.610	0.89	89.00	5
Cost of repairing errors and defects	4.44	0.616	0.89	88.80	6
Inspection and maintenance of construction equipment	4.41	0.584	0.88	88.20	7
Cost of purchase or renting new equipment	4.41	0.640	0.881	88.20	8
Cost of securing and protecting the site	4.39	0.624	0.878	87.80	9
Labor cost (experienced in sustainable buildings)	4.39	0.609	0.878	87.80	10
Energy cost	4.38	0.571	0.877	87.60	11
Use of full equipment capacity	4.38	0.623	0.877	87.60	12
Cost of installation of equipment and tools	4.37	0.649	0.875	87.40	13
Professional fees such as engineers and consultants	4.37	0.634	0.874	87.40	14
Right-sizing of construction equipment	4.36	0.603	0.871	87.20	15
Cost of using existing equipment	4.34	0.648	0.868	86.80	16
Average	4.41	0.617	0.883	88.26	

Table 3 demonstrates that all 16 factors listed are crucial for the sustainable implementation on construction sites, as indicated by the Relative Importance Index (RII) values exceeding 0.40. The RII for economic factors, from the contractor's perspective, shows these factors are extremely important, with values above 0.4, as detailed in Table 1.

The effectiveness percentage of economic sustainability factors was ranked based on their impact on sustainable implementation on construction sites. A higher effectiveness index percentage signifies a greater importance in influencing sustainable practices. Water cost has the highest effectiveness percentage at 90.20%, while the cost of using existing equipment has the lowest at 86.80%. Nonetheless, all factors fall within the range of being extremely important, according to the effectiveness percentage value interpretation in Table 2, and are absolutely essential to consider when implementing sustainable practices.

Contractors particularly believe that water cost has the most significant influence on the implementation of sustainable practices on construction sites. This finding is supported by a study conducted by Enshassi et al (2016), which identified water cost as the most critical factor affecting the sustainable performance of practices during the construction phase, due to the high costs associated with managing water resources from surface and groundwater.

Table 4
Relative Importance Index (RII) and Effectiveness Index (EI) Percentage of Social Factors

Social Factors	**Mean**	**Standard Deviation**	**RII Value**	**EI (%)**	**Ranking**
Project control guidelines	4.46	0.618	0.892	89.20	1
Creating jobs due to the need of labours	4.43	0.622	0.885	88.60	2
Health and safety at workplace	4.42	0.622	0.885	88.40	3
Creating jobs for local employment directly	4.41	0.635	0.883	88.20	4
Participation of all parties in project monitoring and decision-making	4.41	0.627	0.881	88.20	5
Working conditions	4.4	0.633	0.88	88.00	6
Physical space of the building	4.38	0.608	0.877	87.60	7
Improvement of infrastructure to the society and environment	4.38	0.643	0.876	87.60	8
Labor availability	4.37	0.613	0.874	87.40	9
Increased burden on infrastructure because of the use and depletion of natural resources	4.37	0.675	0.874	87.40	10
Influence of the project on job market	4.36	0.631	0.871	87.20	11
Promotion and development of capacity and skills for the labour force	4.36	0.638	0.871	87.20	12
Reliance on intensive labour rather than intensive equipment	4.35	0.637	0.87	87.00	13
Availability of knowledge and skills in the labour force	4.33	0.604	0.867	86.60	14
Public awareness	4.33	0.618	0.866	86.60	15
Creating jobs for local employment indirectly	4.32	0.669	0.863	86.40	16
Aesthetic options of the building	4.3	0.672	0.861	86.00	17
Average	4.38	0.633	0.875	87.51	

The Relative Importance Index (RII) for the 17 social sustainability factors listed in Table 4 has values of 0.6 and above, classifying them as extremely important factors affecting the implementation of sustainable practices on construction sites.

Both the RII values and effectiveness index percentages indicate that project control guidelines are rated as the most critical factor for social sustainability implementation, with an RII of 0.892 and an effectiveness percentage of 89.20%. In contrast, aesthetic options for the building are rated as the least important factor, with an RII of 0.861 and an effectiveness percentage of 86.0%. This suggests that contractors prioritize project guidelines and regulations over the artistic design of buildings.

Contractors believe that project control guidelines have the most significant influence on the implementation of sustainable practices on construction sites. According to Hirpara & Kashiyani (2018), project control is essential for ensuring that project goals are met. In the construction of sustainable buildings, sustainable project management is established to manage the project organization in implementing sustainable practices on construction sites, encompassing both control mechanisms and the alliance contract of the project partners.

Table 5
Relative Importance Index (RII) and Effectiveness Index (EI) Percentage of Environment Factors

Environment Factors	**Mean**	**Standard Deviation**	**RII Value**	**EI (%)**	**Ranking**
Health and safety risks	4.65	0.562	0.930	93.00	1
Integrated environmental and economic program	4.60	0.574	0.920	92.00	2
Pollution generation	4.57	0.586	0.915	91.40	3
Waste management	4.57	0.579	0.914	91.40	4
Environmental regulations	4.56	0.572	0.913	91.20	5
Ecology preservation	4.56	0.572	0.913	91.20	6
Management of surplus materials	4.56	0.588	0.911	91.20	7
Reuse of products	4.55	0.596	0.910	91.00	8
Environmental management technology	4.55	0.573	0.909	91.00	9
Changes in the environment lead to the discomfort of people and the biological system.	4.55	0.588	0.909	91.00	10
Recycling of products	4.54	0.604	0.908	90.80	11
Site attributes	4.54	0.589	0.908	90.80	12
Natural habitat destruction	4.54	0.589	0.908	90.80	13
Inclusion of environmental aspects in decisions during construction (e.g. buying greener materials)	4.54	0.582	0.907	90.80	14
Use of sustainable temporary facilities (such as desks and bathrooms) during the project	4.54	0.574	0.907	90.80	15

Institutional interest to the environmental aspect	4.53	0.582	0.906	90.60	16
Use of sustainable material substitutions	4.51	0.598	0.902	90.20	17
Depletion of dependency resources (water-energy-raw materials-land)	4.51	0.59	0.902	90.20	18
Use of recyclable/renewable materials	4.50	0.583	0.900	90.00	19
Waste generation	4.50	0.59	0.900	90.00	20
Waste disposal	4.50	0.59	0.900	90.00	21
Communication of environmental management information	4.49	0.583	0.899	89.90	22
Average	4.54	0.584	0.909	90.87	

The environmental sustainability factors in this research study consist of 22 elements that need to be analysed based on their effectiveness in influencing sustainable practices on construction sites. Table 5 shows the analysis of each factor, revealing that all factors have a Relative Importance Index (RII) value above 0.5, indicating their extreme importance.

Among the environmental sustainability factors, health and safety risks of construction work is identified as the most important, with an effectiveness of 93.0% (RII = 0.930). In contrast, communication of environmental management information is considered the least important aspect, with an effectiveness of 90.80% (RII = 0.908). Contractors believe that health and safety risks have the most significant influence on the implementation of sustainable practices on construction sites. According to Marhani et al. (2012), citing Bashir et al. (2011), to improve the performance of construction companies and ensure their safety and health, a proper health and safety assessment should be implemented in construction projects. Therefore, it is crucial to establish safety and health guidelines on construction sites.

Table 6
Relative Importance Index (RII) Value and Effectiveness Index (EI) Percentage Based on Principal Criteria

Principal Criteria	**RII Value**	**Effectiveness Index Percentage (%)**
Economic	0.883	88.26
Social	0.875	87.51
Environment	0.909	90.87

Table 6 summarizes the RII values and effectiveness index percentage for each of the principal criteria affecting sustainable implementation on construction sites. The average RII value for each principal criterion was calculated for interpretation. All the principal criteria which are economic (RII = 0.883, EI = 88.26%), social (RII = 0.875; EI = 87.51%), and environmental (RII = 0.909; EI = 90.87%) were deemed extremely important in this study for sustainable development on construction sites. It is agreed that all the principal criteria are distinctly important as they form the basic components necessary to achieve balanced sustainable development in construction work.

Environmental factors play a crucial role in sustainable construction for several reasons, often outweighing social and economic factors in their immediate impact and long-term significance. The environmental impact of construction extends beyond carbon emissions. It includes issues like water use, habitat destruction, and pollution. Sustainable construction practices aim to minimize these impacts by using eco-friendly materials, reducing waste, and implementing green building techniques (Iyer-Raniga, U. et al, 2021). While social and economic factors are important, environmental sustainability ensures that the construction industry can continue to operate without depleting natural resources or causing irreversible environmental damage. This long-term perspective is crucial for the industry's future.

In summary, while social and economic factors are important, the environmental impact of construction is immediate and far-reaching, making it a critical area of focus for sustainable practices.

Conclusion

The primary objective of this research is to analyze the factors that contribute to the implementation of sustainable practices on construction sites. This objective is achieved through comprehensive data analysis conducted in this study. The analysis revealed that all 55 factors, categorized under the key principles of sustainability (economic, social, and environmental), were classified as extremely important according to both the Relative Importance Index (RII) and the Effectiveness Index (EI). Specifically, the most critical factors identified were water cost (economic), project control guidelines (social), and health and safety risks (environmental).

The second objective of this research is to evaluate the effectiveness of these factors in promoting sustainability practices on construction sites. The Effectiveness Index (EI) method was employed to assess the factors and fulfill this objective. The results indicated that all factors were deemed extremely important. Despite minor differences, the ranking method remains valid for identifying the most significant factors influencing the effectiveness of sustainable practices on construction sites. The ranking of factors based on their effectiveness closely mirrors their ranking by the Relative Importance Index, highlighting the strong correlation between the importance and effectiveness of these factors.

In conclusion, the comprehensive list derived from the literature review underscores the extreme importance of all identified factors in implementing sustainable practices on construction sites. This research focuses exclusively on the perspectives of contractors operating in the Klang Valley. Contractors in Malaysia can significantly improve their sustainable practices, contributing to a more environmentally friendly and socially responsible construction industry, by adopting several strategies. These include enhancing their knowledge and education on sustainability practices, involving local communities from the initial phase through to the implementation of construction projects, and promoting awareness campaigns to highlight the benefits of sustainable practices. Furthermore, the government should support and provide financial incentives for projects that meet sustainable criteria to encourage the implementation of sustainable practices.

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