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Original Article

Identification of Priority Criteria for the Advancement of Green Buildings for Commercial Buildings

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Abstract

Nowadays, one of the biggest worldwide problems is resource depletion and environmental damage. The construction industry has taken leading roles in energy conservation and emission reduction since buildings are the primary habitat for humans and are major sources of energy consumption and pollution emissions. In recent years, the concept of sustainability has drawn the interest of numerous disciplines. Green building (GB) is the fundamental element of sustainable development as it defines style of buildings designed and constructed by environmentally friendly principles. In this regard, this study draws attention to evaluating and addressing the most important topics: the priority criteria for advancing GB for commercial buildings. Therefore, to enhance and promote the development of green buildings, it is crucial to comprehend the factors that determine the successful application of green features to ensure that the obstacles during the construction process are overcome. The research identifies key criteria such as energy efficiency, material selection, water conservation, and indoor environmental quality through comprehensive literature reviews, surveys, and case studies. By analysing stakeholder perspectives, including architects, builders, and tenants, this research highlights the most impactful criteria for promoting green building initiatives. The findings offer valuable insights for policymakers, developers, and industry professionals, ultimately contributing to a more sustainable built environment. This study highlights the elements driving the acceptance of green buildings and barriers to their execution, providing valuable insights for stakeholders engaged in the ongoing discourse concerning green building development. Consequently, interested parties will better understand the factors affecting the priority criteria for the progression of green buildings in commercial buildings.

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1. Introduction

1.1. Research Background

The worldwide construction industry has been advocating for sustainability with increasing frequency because of the necessity to reduce the negative effects of the business [1]. Therefore, the increasing global concern for environmental sustainability has catalysed a significant shift in the construction industry towards green building practices. Green development is vital to promoting a more sustainable and environmentally friendly future, with green buildings being a key component of this progress. To balance economic growth and ecological responsibility, greater emphasis must be placed on the long-term sustainability of green building practices. This approach not only addresses society's immediate needs but also ensures that future generations inherit a built environment that supports both environmental preservation and economic resilience. Prioritising green buildings is essential for fostering sustainable national development and creating a foundation for long-term progress [2].

The building and construction industry is one of the largest contributors to global energy consumption (36%) and carbon emissions (37%), posing significant sustainability challenges for the Architecture, Engineering, and Construction (AEC) sector [3]. Addressing these challenges requires a strong focus on resource efficiency and environmental responsibility. In response, there is a growing global movement toward adopting and promoting green building (GB) practices, aiming to reduce environmental impact and create more sustainable built environments [4].

As major energy consumers and contributors to greenhouse gas emissions, commercial buildings play a pivotal role in this transition [5]. The worldwide buildings can prove that they consume 30-40% of the primary energy and are accountable for 40 to 50 per cent of greenhouse gas emissions. They use a significant amount of energy and the available natural resources. Therefore, they also play an important role in the socioeconomic growth of a country. Malaysia's carbon emissions increased by 221% between 1990 and 2004, increasing the country's energy demand from the transport and industrial sectors [6]. This growth rate has been termed the fastest in the world. Also, Malaysia's national energy demand grew by 210.7% between 1990 and 2009, resulting in a +235.6% rise in carbon emissions [7]

The world is currently at a critical point in its energy transition due to the rapid decrease of fossil resources and increasing concern over climate change [8]. In this context, hybrid renewable energy systems (HRES), particularly those integrating wind and solar technologies, have emerged as celebrated solutions to the challenges of building energy sustainability. They combine the best of both worlds to solve the problems associated with energy sustainability. Due to the urgent problem of climate change, renewable energy solutions must replace fossil fuel-based energy systems. Some renewable technologies, like solar and wind energy, can be applied in those buildings to enhance the sustainability goals.

1.2. Literature Review

1.2.1. Introduction of Green Buildings

Green building encompasses the design of a structure and the integration of sustainable practices throughout its life cycle. This includes every stage, from initial planning and design to construction, operation, maintenance, renovation, and eventual demolition. The approach prioritises environmental responsibility and efficient resource use, ensuring that buildings are developed and managed to minimise their ecological footprint while enhancing long-term sustainability [9]. Sustainable building is a complex and wide-ranging field. However, there is a shared understanding that thoughtful design

is key, such as choosing the right construction methods and materials. This decision can significantly enhance a building's performance and efficiency over its lifespan [10].

Green buildings are structures designed to prioritise environmental responsibility and efficient resource use at every stage of their life cycle [11]. This includes construction, operation, maintenance, renovation, and eventual demolition, ensuring sustainability is upheld throughout the building's lifespan.

Figure 1 comprehensively depicts a green home designed with sustainability and energy efficiency in mind. The house incorporates various eco-friendly features to minimise environmental impact and enhance indoor comfort. Photovoltaic panels on the south side generate electricity for energy conservation, while a solar-powered water heater further reduces reliance on non-renewable resources. The structure utilised metal and light-coloured roofing, energy-efficient impassive windows, and well-insulated exterior walls to regulate indoor temperatures effectively. Moreover, water conservation is addressed through rainwater collection, low-flow and dual-flush toilets, and a central vacuum system. This green home integrates advanced technologies and thoughtful design choices to promote energy efficiency, resource conservation, and a healthier living environment [12].

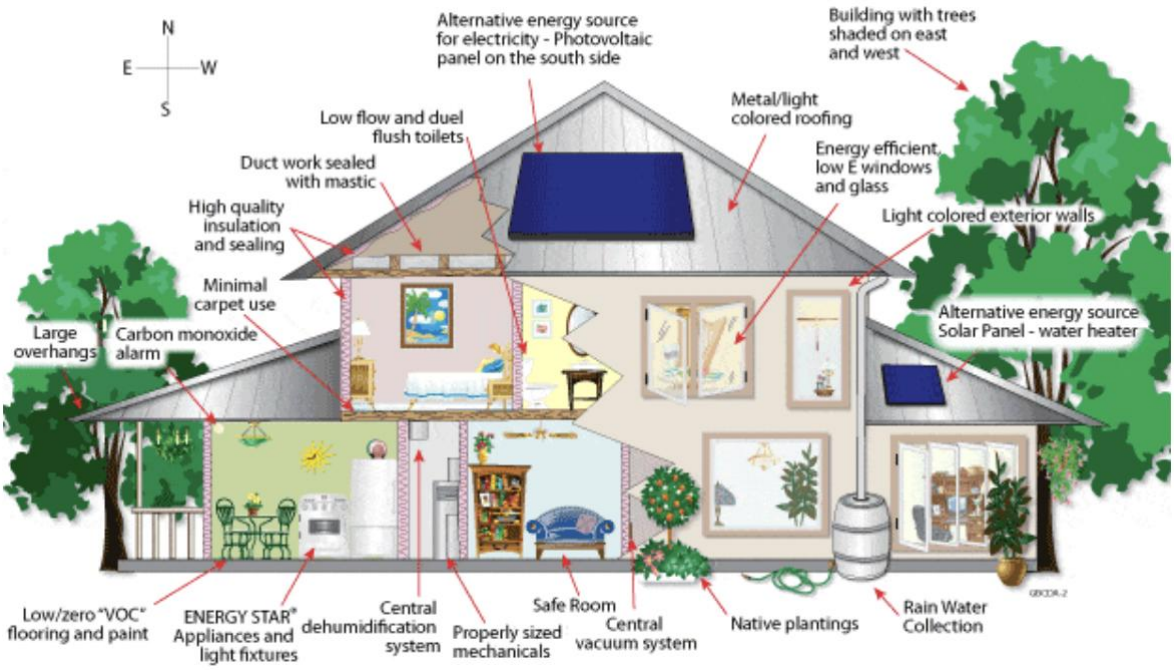

Figure 1: The Conceptual Drawing of a Green Building.

Green buildings are instrumental in enabling cities to meet their environmental objectives by reducing ecological footprints by strategically incorporating innovative technologies in both architectural design and construction practices. These green homes incorporate eco-friendly technologies and energy-efficient solutions to create a comfortable, safe, and healthy living environment for occupants [13]. Despite the well-documented environmental, social, and economic advantages of green buildings, they still make up only a small fraction of overall construction projects in many countries, and their performance does not always meet expectations. Research by Li and Green has shown that building projects often face delays, design modifications, inefficient rework, and excessive production, which can hinder their effectiveness [14]. Therefore, achieving sustainability

goals in green building projects requires multiple design refinements, advanced simulations, in-depth analyses, and stricter on-site precautions. These added complexities make the project management process more intricate and demanding [15].

Figure 2 illustrates the lifecycle of a green building, emphasising key sustainability considerations at each phase. It highlights the interconnection between design, construction, operation, maintenance, and demolition while addressing critical environmental challenges such as energy efficiency, water conservation, material selection, and waste management. The process begins with the pre-building phase, where design is crucial in incorporating energy-efficient and renewable solutions, water-saving strategies, and sustainable material choices. During construction, careful selection of materials and systems minimises environmental impact, while efficient waste management practices promote recycling and reuse. The operation and maintenance phase focuses on sustaining building performance, ensuring long-term resource efficiency, and reducing energy consumption. In the demolition and disposal phase, material reuse and recycling minimise waste and environmental degradation. As a result, to create cities that can thrive in the long run, it is crucial to embrace green building practices that prioritise sustainability, resource efficiency, and environmental responsibility [16].

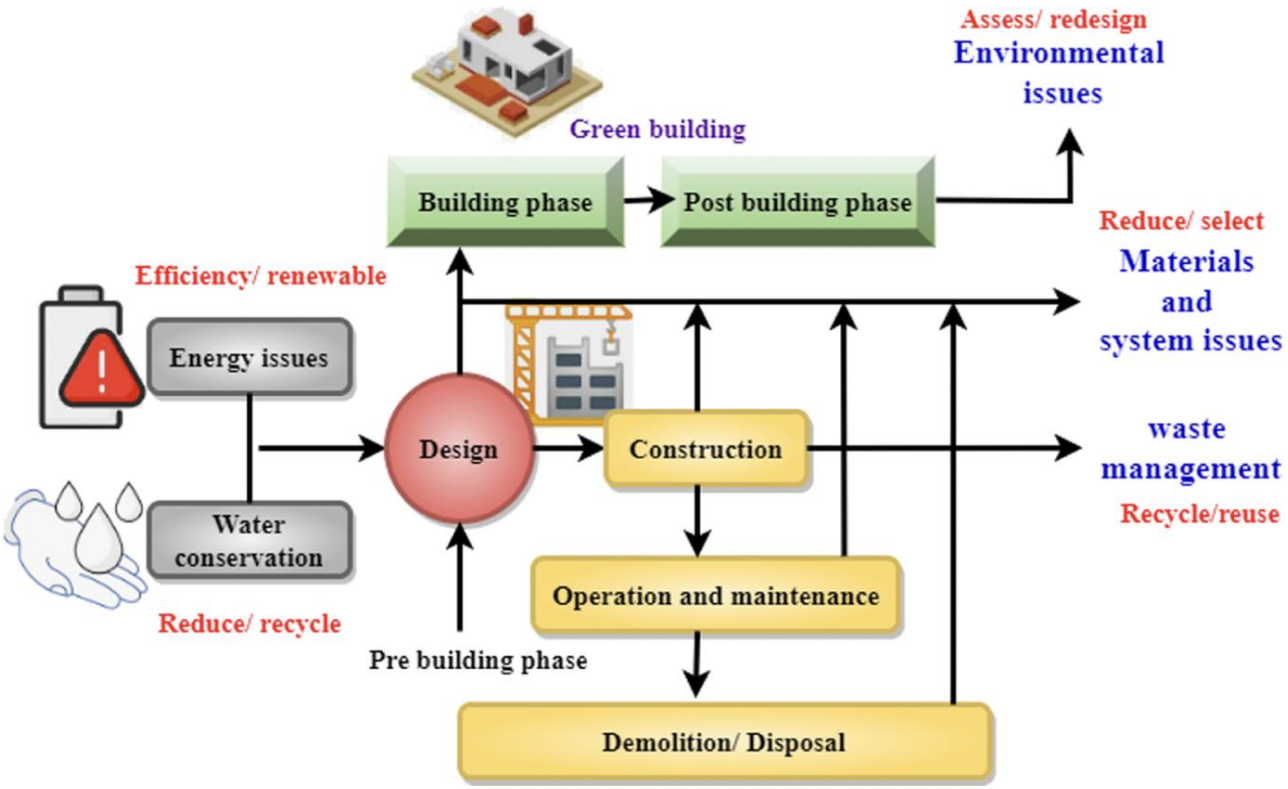

Figure 2: The Construction and Maintenance of a Green Building.

1.2.2. Benefits of Green Building Practices

Contribution towards Economic and Social Growth

Moreover, green buildings are becoming increasingly appealing because of their additional benefits and incentives, which can help shape a brighter future for the construction industry and contribute to a healthier planet. The push to build more green buildings is driven by their positive impact on economic

and social development and environmental conservation [17]. All parties profit greatly from green buildings' effective contributions to life quality and improved life ability for coming generations [18]. Despite that, it stated that a shortage of studies and research on the expenses and advantages of green buildings limited the chance to value this investment for today. The benefits of green buildings extend beyond economic and environmental advantages, encompassing significant social and cultural impacts. From the financial aspect, green buildings help save energy and water throughout their lifespan. As a result, this can help reduce the cost for society and conserve resources. On the other hand, green buildings can effectively manage sewage and minimise water pollution. Additionally, in terms of social, green buildings generate financial savings for governments and communities. Culturally, they promote a green corporate culture to encourage businesses to embrace environmental and social responsibility, thus creating a positive cycle between enterprises and the environment [19].

Economic Advantages

Also, there is an increasing practice of preserving clean hot or cold air while highlighting the economic advantages of green building [20]. For instance, the California Academy of Sciences building is one example, which has motorised windows to let cool air in and vents in the domes to remove hot air (Green building integrates). Even while these techniques effectively regulate a building's temperature, maintaining air quality is just as crucial given that people spend 80–90% of their time indoors. This shows that green buildings bring a lot of benefits to their users and the environment. Green buildings have 14 points of interest [21]. These include water and necessity savings, lower maintenance costs, increased property value, residential development in productivity, and a 5% decrease in non-appearance. Other benefits include comfort, danger, attraction, and intensity.

Thermal Comfort

Building occupants in green buildings enjoy enhanced thermal comfort due to energy-efficient design features such as natural ventilation, passive heating and cooling, and high-performance insulation materials. For instance, warm extravagance, which is composed of several interconnected components of temperature and humidity, is associated with the benefit of building users. This has involved sweeping, scholarly thought to wear, and examining the warm, extravagant effort in green filling in as distinct and common structures [22].

2. Methodology

2.1. Research Philosophy

Research philosophy refers to the underlying beliefs that guide how a researcher views and engages with the world. It provides the conceptual foundation for interpreting reality, generating knowledge, and applying theoretical approaches that support the chosen research methodology. In essence, the guiding perspective influences the entire research process, from data collection to analysis and interpretation. Various research philosophies exist, each offering distinct approaches for researchers to obtain meaningful information for their studies. Common types of research philosophies include positivism, realism, interpretivism, and pragmatism, among others.

In the context of this study, research philosophy is grounded in pragmatism. It adopts a mixed-methods approach that blends quantitative and qualitative techniques for data collection. This methodology facilitates a more comprehensive understanding of the research problem by integrating various data sources and viewpoints.

2.2. Research Design

A research design can be defined as the systematic approach that a researcher follows to answer research questions validly and reliably. It is because it outlines the sequential process of reaching the objectives of a study, from its inception to its completion. It is objective and precise, guiding the researcher in selecting the appropriate data collection and analysis methods to achieve the desired outcomes. The design typically dictates the type of analysis needed to obtain accurate results. In other words, to ensure the investigation is conducted smoothly and effectively, the research design functions as a structured framework that enables the researcher to understand the entire study better. It facilitates the efficient and accurate collection of meaningful data. It is the foundational blueprint for scientific inquiry, encompassing the tools, methods, and protocols employed throughout the research process. Additionally, the research design helps identify potential challenges and provides solutions for addressing issues that may arise during the research and analysis stages [23].

2.3. Research Process

Figure 3 shows a framework of the research design for the research paper. The study design framework comprised five consecutive procedures, spanning from the initial to the research's final phase. The 5 processes included in the research process are as follows: Preliminary Research, Literature Review, Research Methodology & Data Collection, Data Analysis, Results and Discussion, and finally, Conclusion and Recommendations.

Determining the research problem is the first step during the initial investigation regarding the chosen title. Subsequently, the study's enquiries and goals are determined following the previously described research issue. The extent of the research is also established in this step. Subsequently, the researcher identifies and reviews relevant sources to complete the literature review, refining the key criteria for advancing green building practices in commercial buildings. Appropriate sources for obtaining secondary data include journals, articles, theses, books, websites, and other credible materials. The criteria influencing green building practices will be derived from existing research and incorporated into the questionnaire, distributed to professionals such as architects, building surveyors, government representatives, contractors, and other stakeholders for their feedback [24].

The next phase of this section includes the research methodology and data collection process. Moreover, it also encompasses the identification of appropriate research methods, data collection procedures, and sample techniques. This research will use a mixed method, including quantitative and qualitative methods. The data collection through quantitative methods includes questionnaires, with the sampling strategy utilised being simple sampling, which is one of the available purposive sampling methods for analysing the criteria that affect the green building practices. Next, the qualitative method used is semi-structured interviews; this method was chosen for data collection on identifying the barriers and challenges commercial buildings face in adopting green building technologies and practices and prioritising a framework for stakeholders involved in the commercial building sector, aimed at fostering adaptation of green building initiatives. This approach will help ensure that the perspectives of key industry participants are considered when evaluating the factors that impact the adoption and implementation of green building practices.

The next stage of the study involves data analysis, followed by presenting and discussing the results. Data collection from the questionnaire and interview session will be thoroughly examined and analysed. The questionnaire will use the SPSS method to analyse the data collected through online surveys. The data collected through the interview session will be processed using the thematic analysis method, which can allow for the identification of key patterns and themes [25].

Finally, a summary of the results will be presented at the end of the methodology. The findings will include recommendations and identify potential constraints, offering stakeholders valuable insights into the priority criteria that influence the effectiveness of green building practices, particularly in commercial buildings.

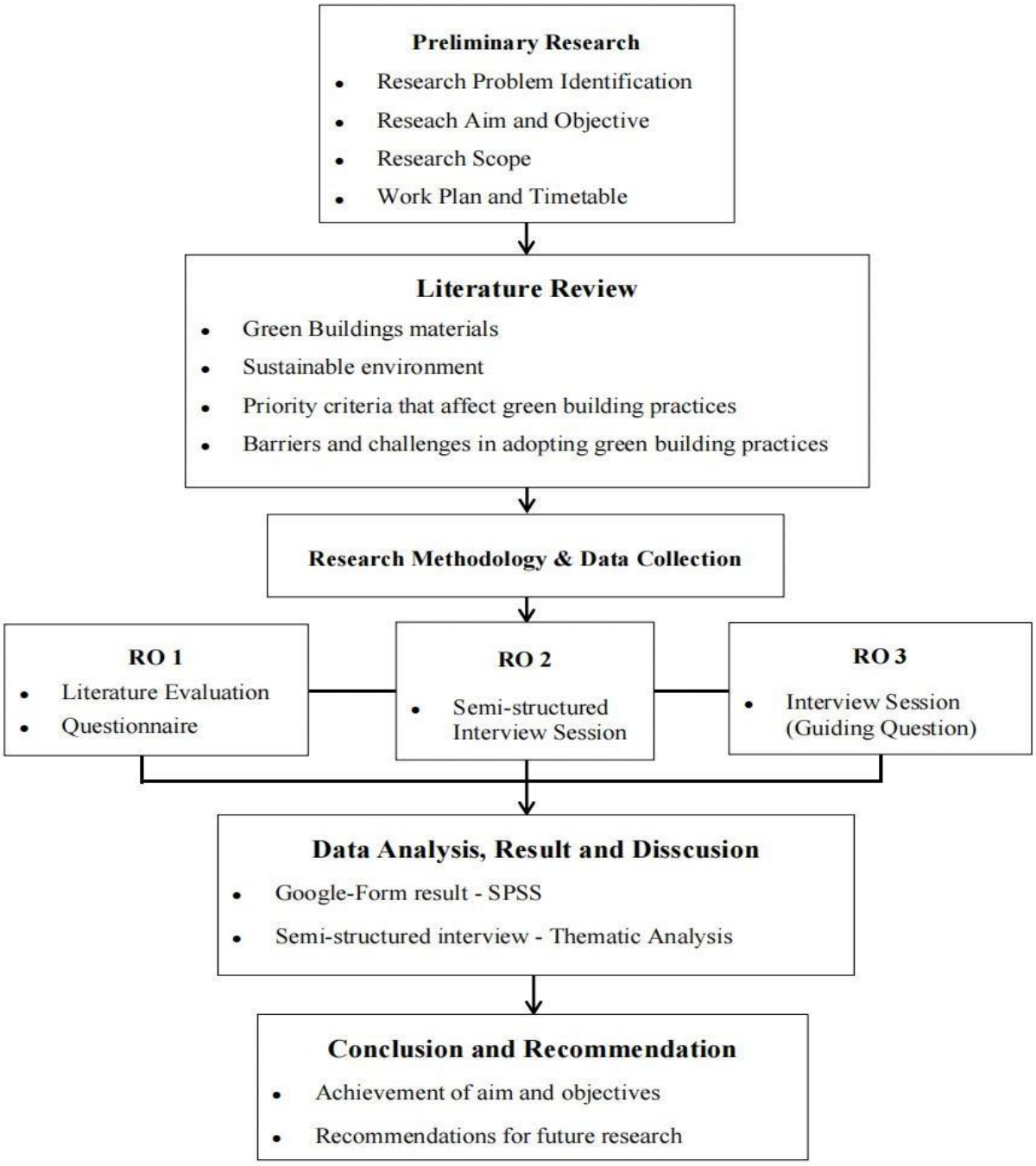

Figure 3: Research Framework for Identification of Priority Criteria for the Advancement of Green Buildings for Commercial Buildings.

2.4. Interview Session Development

To achieve the third objective of this research, a guided-question interview approach was employed to gather insights from key stakeholders in the commercial building sector (see Table 1). Participants

included architects, engineers, property developers, and facility managers, all playing a crucial role in green building adoption. The structured yet flexible nature of the interview allowed participants to elaborate on their perspectives regarding the prioritised framework for stakeholders involved in the commercial building sector. This method ensured a balanced approach, offering a structured framework for discussion while allowing stakeholders to express nuanced opinions based on their expertise and experiences.

Using guiding questions allowed the study to maintain consistency across interviews, facilitating effective comparison and analysis of participants' responses. The structured approach helped identify recurring themes, ensuring stakeholder feedback was systematically categorised and assessed. These insights were instrumental in shaping a prioritised framework that aligns with industry needs and practical feasibility. The qualitative data from the interviews was then analysed to extract key recommendations, providing a well-rounded understanding of the most critical criteria for advancing green building practices in commercial developments.

2.5. Sampling Method

For this research, the sampling method utilised is probability sampling, where every individual in the population has a known and equal chance of being selected (see Figure 4). Within probability sampling, purposive sampling can be used, where researchers intentionally select participants with specific characteristics or knowledge relevant to the study, ensuring that the sample is highly focused on the research objectives. For example, the respondents are from a diverse range of professional building actors within the construction field. The questionnaire was filled out by Malaysian green building experts, managers, building surveyors, local authorities and other professionals. This diversity will ensure that a wide range of perspectives and expertise are incorporated into the analysis. By engaging with these stakeholders, the research aims to uncover the nuanced ways different criteria contribute to the effectiveness of green practices in commercial buildings.

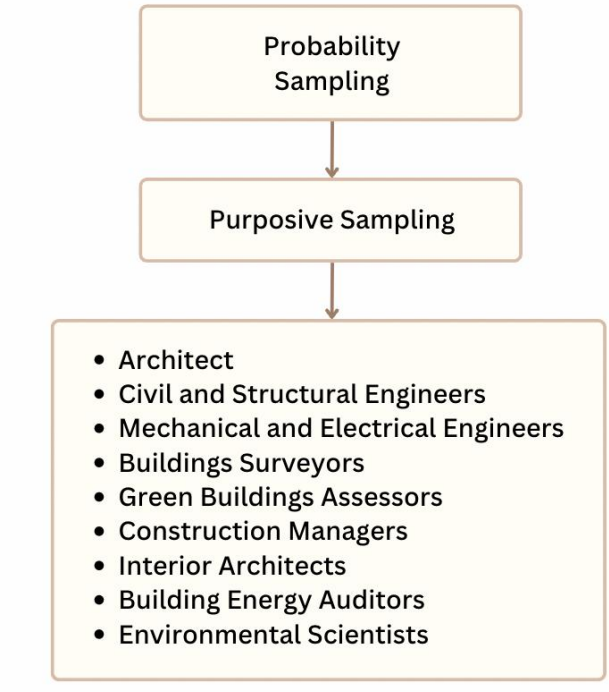

Figure 4: Sampling Method - Probability Sampling.

Table 1: Interview Questions.

Interview Questions
1. Can you briefly introduce yourself and explain your role within the commercial building sector?
2. How long have you been involved in green building initiatives or sustainable construction practices?
3. What is your current perspective on green building adoption within the commercial construction sector, particularly in your region?
4. What are the key drivers behind the push for sustainability in commercial buildings, from your experience?
5. Which specific green building practices or technologies should be prioritised to achieve the greatest impact on sustainability in the commercial sector?
6. How do you think government policies or incentives can help accelerate the adoption of green building standards?
7. From your point of view, what role do stakeholders, such as architects, developers, contractors, and facility managers, play in promoting green building practices, and how can they collaborate effectively?
8. What metrics or standards are essential for measuring the success of green building initiatives within the commercial sector?
9. Lastly, what are the most critical areas for innovation or improvement in commercial green building practices in the next 5 to 10 years?

3. Results

Thematic analysis was used to interpret and analyse the data from the guided-question interview sessions. This approach involved systematically identifying patterns and recurring themes within the responses, allowing for a structured understanding of stakeholders' perspectives on the prioritised framework for implementing green building practices. The interview data was carefully transcribed to ensure accuracy and completeness before being categorised into key themes related to prioritising the key framework for executing green building practices in commercial sectors. By grouping similar ideas and viewpoints, thematic analysis enabled the study to highlight common challenges, recommendations, and critical factors influencing green building adoption. This method provided a clear and organised framework for analysing qualitative data, ensuring meaningful insights were extracted to support the research objectives.

Material selection is pivotal in ensuring sustainability and promoting green construction, which minimises environmental impact and reduces resource depletion. The decision to use sustainable materials directly influences the overall carbon footprint of a building throughout its lifecycle, from production and transportation to installation, use, and eventual disposal or recycling [26–48]. Choosing environmentally responsible materials, such as those with low embodied energy, low carbon emissions, and renewable or recycled content, conserves natural resources and helps reduce waste and pollution [49–56]. Materials like bamboo, reclaimed wood, and recycled steel offer durability and can be sourced locally, which reduces the energy required for transportation and supports the local economy [57]. Additionally, these materials often feature natural thermal properties, contributing to the structure's overall energy efficiency by reducing the need for heating and cooling [58–63]. Green construction emphasises using materials that have a lower impact on the environment, favouring non-toxic, biodegradable, or recyclable materials, thus improving indoor air quality and contributing to the health and well-being of occupants [64]. Sustainable material choices also extend to water efficiency, with materials that conserve water during usage or construction and those impervious to moisture or pests, thereby reducing maintenance and extending the lifespan of buildings [65]. Moreover, the durability and longevity of materials impact the frequency of repairs, renovations, and replacements, further minimising resource consumption and waste generation over time. Integrating innovative materials, such as energy-efficient glass, reflective roofing, and low-impact insulation, enables buildings to

harness natural light, reduce heat absorption, and optimise energy consumption, ultimately resulting in both resource-efficient and cost-effective buildings.

Furthermore, advancements in material science, such as the development of bio-based and low-carbon alternatives to conventional cement, allow for even greater reductions in environmental impact, addressing the construction industry's heavy reliance on resource-intensive products. The promotion of life-cycle assessments (LCAs) in material selection also ensures that the ecological consequences of material choices are thoroughly considered, encouraging the use of renewable resources, the reduction of embodied energy, and the selection of materials that can be recycled or reused at the end of their life. With building codes and regulations increasingly supporting sustainable construction practices, the responsible selection of materials is no longer just a design choice but a necessity to meet sustainability goals and adhere to green building standards like LEED and BREEAM [66–74]. Furthermore, by prioritising sustainable materials, construction projects help mitigate climate change and contribute to a circular economy, where materials are continuously reused and recycled, reducing the need for virgin resources [75–77]. The growing demand for green buildings and eco-conscious designs also stimulates innovation in material technologies, pushing manufacturers to develop new, more sustainable options that are both environmentally friendly and economically viable, contributing to the growth of the green construction sector. By considering the full impact of materials on the environment, economy, and society, builders, architects, and developers can create spaces that align with the values of sustainability, resilience, and environmental stewardship, making material selection one of the most influential factors in advancing green construction and achieving a more sustainable future.

4. Conclusions

In conclusion, by establishing a structured framework, stakeholders can navigate these challenges more effectively, ensuring that sustainability goals are met without compromising financial and operational viability. Key factors such as policy interventions, financial mechanisms, stakeholder collaboration, and technological advancements must be prioritised to accelerate the green building movement. Future research should focus on validating the proposed framework through empirical studies and real-world applications to refine and enhance its effectiveness. A strategic and well-informed approach is necessary to drive the commercial building sector towards a greener and more sustainable future.

Declaration of Conflict of Interest

The authors declared no conflict of interest with any other party on the publication of the current work.

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