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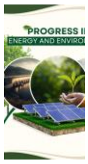

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Original Article

Developing a Conceptual Framework for Advancing Green Buildings in Commercial Real Estate

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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 the 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

Glavinich [1] emphasises that there are multiple definitions of green construction nowadays. Generally, a green building can be described as an approach that aims to reduce the environmental impact of a building while also improving its ecological, economic, and social performance. The concept of green building has gained more attention in the last two decades than in the previous one. It is due to construction processes that are essential to identifying the suitable solutions for global issues like waste collection, water and energy scarcity, etc.

The word "sustainability" is used a lot these days. Jarvie, Michelle. The Brundtland Report [2] stated that the word "sustainable development" was defined as "development that satisfies the needs of the present generation without compromising the ability of future generations to satisfy their own needs." Furthermore, definitions of "sustainability" emphasise its significance to issues related to the economy, society, and environment. A growing awareness of environmental issues and sustainability concerns increasingly shapes the contemporary landscape of architecture and construction. As global temperatures rise and urban populations expand, the built environment is critical in exacerbating and alleviating climate change's impacts [3]. A key area when considering environmental sustainability is sustainable construction. Due to its advantages, governments, environmentalists, and other stakeholder groups are pursuing sustainable construction as a strategy [4]. Therefore, green buildings—designed to minimise environmental impact while optimising occupant comfort and resource efficiency—have emerged as a vital solution. Hafez et al. [5] This research project aims to identify and prioritise the criteria necessary for advancing the development and implementation of green buildings. By focusing on key metrics that determine the efficacy of green practices, this study seeks to contribute meaningful insights to the field and promote sustainable practices within the construction industry

1.2. Literature Review

1.2.1. Introduction of Green Buildings

"Green building" is frequently called an energy-efficient, environmentally friendly, or sustainable building [6]. However, there are a lot of variations in the definitions of green buildings. According to American architects Paola Soleri and Ian Lennox McHarg, the term "green" emphasises sustainable development that prioritises people to achieve a harmonious relationship of architecture, nature, and humankind. The term "green" in "green buildings" does not refer to the vertical greening or green roof gardens but rather symbolises a broader concept of environmental responsibility. It is designed to achieve a balanced relationship between humans and nature, promoting sustainability and long-term ecological harmony [7]. Green buildings have evolved as a global response to the environmental impact of commercial building development and operation [8]. "Green" describes methods that benefit the environment, including landscaping and architectural design [9]. Based on a study conducted by Chan et al. [10], the research mentioned that the need to improve the sustainability performance of buildings has grown to be a top priority for the construction sector. Green buildings are not just environmentally friendly; they also play a crucial role in creating comfortable spaces for work and living, ultimately enhance the quality of life. Building green structures would significantly reduce environmental harm and better use resources.

Also, based on the findings identified by Ries et al. [11], the increasing practice of preserving clean hot or cold air highlights the economic advantages of green buildings. 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 benefit their users and the environment.

1.2.2. Priority Criteria for the Advancement of Green Buildings

The definition of sustainable building principles aims to reduce the impact of a building's life cycle. To achieve sustainable buildings to help with issues of environmental impact, the International Council for Research and Innovation in Building and Construction (CIB) working commissions came up with several proposals. Creating green buildings is one of them. According to the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE), a green building design achieves excellent performance over its life cycle. Certain criteria are listed to be rated to identify if the buildings meet the requirements [12]. The Green Building Rating System (GBRS) was created to assign rating points for buildings that reach certain requirements and show whether or not their designs are environmentally friendly [13].

Figure 1 indicates the Green Buildings Index Malaysia (GBIM) criteria and sub-criteria. According to the study of Retno Rahardjati et al. [23], six criteria were stated in the current GBIM. There are Energy Efficiency (EE), Indoor Environmental Quality (IEQ), Sustainable Site (SS), Material & Resources (MR), Water Efficiency (WE), and Innovations (IN). Energy Efficiency has the biggest distribution among the six criteria. Two levels and a target have been set up through the analysis process. The six primary GBIM criteria are categorised as level 1, each with a level 2 sub-criterion.

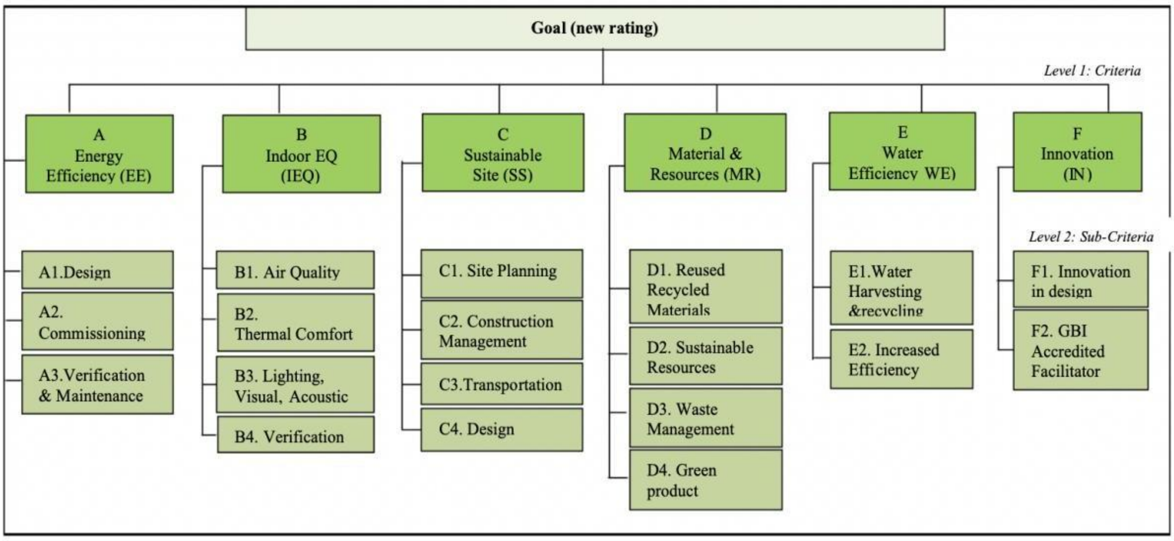

Figure 1: Criteria and Sub-criteria of GBIM [14].

1.2.3. Water Efficiency

Moreover, one of the key criteria of green buildings is reducing water consumption and maintaining its quality. This can be achieved throughout a building's lifespan by installing dual plumbing systems that recycle water for toilets and car washes and using water-saving fixtures such as low-flow shower heads, bidets, and ultra-low flush toilets. Other technologies are also in use, such as collecting rainwater and reusing greywater [15]. Since water is becoming a limited resource, an assessment or a way to calculate how much water a building uses is necessary. Hence, the water conservation index determines each building's water-saving rate and whether it can be certified as a green building or needs to be renovated to incorporate water-efficient design elements. In this regard, Cheng et al. [16] have carried out research related to assessing a building's water efficiency in Taiwan. The study investigated the average water-saving rate for 1320 buildings with green building certification between 2000 and 2013. Therefore, based on the fundamental water use rate, it has been found that an average of 37.3 per cent savings is made for all green buildings. This approach requires projects to reduce water usage by at least 20% to qualify for green building certification.

The layout of a self-sustainable low-cost rainwater harvesting system is shown in Figure 2. As illustrated in Figure 2, rainwater is collected from the roof through two drainage points connected to PVC pipes. These pipes are joined by a T-junction, with one pipe sloping slightly towards the T-point. The third end of the T-junction connects to a U-shaped curve that helps settle dust before directing the water to the other side. LDR and turbidity sensors are installed at the U-point to monitor the rainwater. The ground system is linked between the PVC pipes and the water tank. Water is separated into the ground subsystem, which has two outlets: one for dirty water, directed to the ground for gardening, and the other for clean water, routed to the groundwater tank.

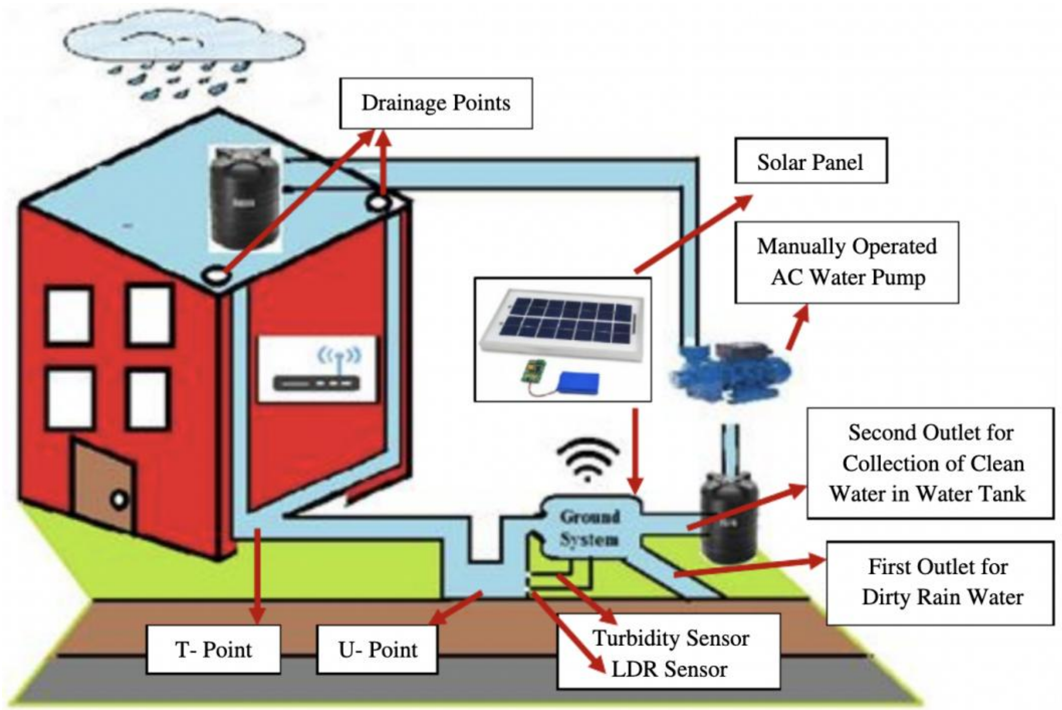

Figure 2: Layout of the Self-sustainable Low-Cost Rainwater Harvesting System [16].

Eneh and Nnaji [17] stated that, in 2004, less than 50% of the population in 20.7% of African countries had access to clean drinking water, while 40% lacked a portable water supply. Therefore, various countries facing water shortages have adopted harvesting rainwater as an alternative water source. This is one of the green building concepts. Law No. 28 of 2002 on buildings, which mandates that all development activities take care to balance with the surrounding environment and not hurt it, supports the idea of green building, which can save water and energy and lessen the burden of pollutants. As a result, rainwater collection and storage can lower the water distribution costs in a building [18].

1.2.4. Indoor Environmental Quality (IEQ)

Since people nowadays spend most of their time in an interior environment, indoor environmental quality (IEQ) is one of the key variables influencing occupants' physical and mental well-being [19]. In recent years, green buildings have gained popularity as a way of lowering energy consumption and enhancing human health and IEQ [20]. Research indicates that certain interior environment discomfort symptoms, such as the rate of Indoor Air Quality (IAQ), might significantly affect occupant' ability to perform their best at work [21]. Two main design strategies are typically used to improve indoor air quality (IAQ) in a building. The first involves increasing ventilation rates to reduce air pollutants. The second focuses on minimising pollution sources inside and outside the building to prevent contaminants from entering the indoor environment [22]. Indoor environmental quality, according to the Centres for Disease Control and Prevention, is the state of a building or place that impacts the health and well-being of its occupants. Improved occupant well-being is linked to the advantages of enhancing indoor environmental quality through sustainable design techniques.

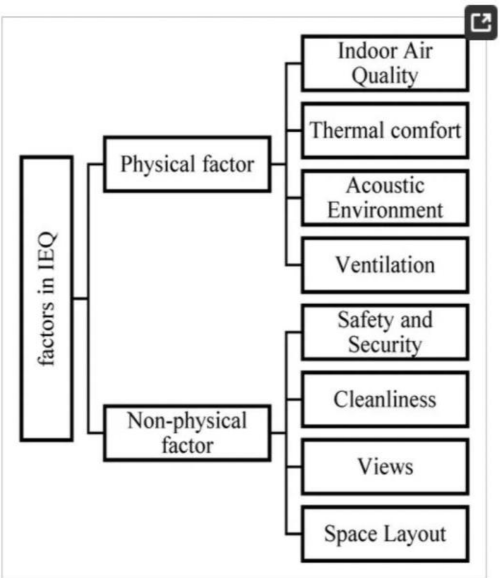

Figure 3: Physical and Non-physical Factors in IEQ Studies.

Figure 3 shows that the factors affecting the IEQ and occupants' health can be grouped into physical and non-physical aspects. Four elements are physical factors: IAQ, thermal comfort, acoustic environment, and ventilation. These factors can be quantified using corresponding measurable parameters. However, non-physical factors are more subjective and challenging to assess with instruments. These include aspects such as safety and security, cleanliness, the quality of views, and the arrangement or layout of space, all of which contribute to the comfort and functionality of a space but are not easily captured through traditional measurements.

1.2.5. Selection of Green Building Materials

On top of that, according to Singh [23], previous research has concluded that one of the key priorities for the advancement of green buildings is the selection and utilisation of sustainable materials. Green materials include recycled or reused items, products created using sustainable methods, locally sourced materials, or those made from eco-friendly resources. These materials play a key role in creating healthy and sustainable buildings that benefit both the people living or working in them and the environment. They also help tackle the urgent challenge of reducing greenhouse gas emissions from the construction industry. In addition to material selection, the green building process must focus on incorporating environmental considerations into every stage of construction, from the initial design choices to the ongoing operation and maintenance of the building.

In the study of Shivakumar [24], Table 1 lists a group of building materials, which are renewable and non-toxic. It can be observed that these key components are important in sustainable design and construction. Renewable materials are those green building materials sourced from rapidly renewable resources. Examples include wood, bamboo, cork, straw bales, hempcrete, and more. On the other hand, non-toxic materials do not release harmful chemicals, like natural clay plaster, natural fibre carpets, and recycled glass countertops, ensuring healthier indoor air quality. These materials are essential for health-conscious building practices, often sourced from renewable or biodegradable substances like natural stone, natural hardwood flooring, and non-toxic sealants.

Table 1: Categories of Green Buildings' Materials.

Renewable Materials	Non-toxic Materials
1. Wood	1. Natural Clay Plaster
2. Bamboo	2. Natural Fibre Carpets
3. Cork	3. Linoleum Flooring
4. Straw Bales	4. Cork Flooring
5. Hempcrete	5. Natural Hardwood Flooring
6. Linoleum	6. Natural Insulation Materials
7. Coconut Timber	7. Unpainted or Unfinished Wood Furniture
8. Rattan Vine	8. Recycled Glass Countertop
9. Sunflower Husks	9. Natural Stone
10. Wool Insulation	10. Natural Fibre Wall Coverings
11. Recycled Cotton	11. Non-Toxic Sealants and Adhesives
12. Mycelium Board	12. Recycled Metal

2. Methodology

2.1. Research Process

Figure 4 indicates that 3 stages will be utilised during the research process. Stage 1 represents the preliminary research and literature review, Stage 2 represents the data collection, and Stage 3 describes the results and analysis.

I: In this initial stage, the researcher will conduct a comprehensive and detailed review of previous research on the key criteria influencing green building practices to understand this research's objectives better. After that, the researcher will establish the problem statement and research objectives (RO1, RO2, RO3), determine the scope of study, and select the appropriate methodology. Additionally, the researcher will develop a set of questionnaire questions to achieve RO1 in stage 1.

II: During the data collection stage, the researcher will determine the appropriate methods for data collection. This involves selecting a relevant group of respondents. The research questions that address RO1, RO2, and RO3 will then be distributed to these respondents to collect professional opinions and data, ensuring alignment with the research objectives of this study.

III: During the final stage, the data collected from the questionnaire form will be transcribed and analysed using specific data analysis tools. The researcher will organise and synthesise the results from the interview session. The RO1, RO2, and RO3 findings will be integrated with insights from the literature review to ensure a comprehensive analysis.

2.2. Literature Evaluation

Literature evaluation allows for a thorough review of existing research, providing insights into various factors influencing green building effectiveness. By relying on peer-reviewed sources, the findings from the literature evaluation are grounded in scientific evidence, enhancing the credibility of the identified criteria. A literature review also offers a comprehensive overview of areas where research may be fragmented or interdisciplinary. Moreover, it effectively synthesises existing research findings, presents evidence at a meta-level, and identifies gaps where further investigation is required. This process is essential for developing theoretical frameworks and constructing conceptual models [25]. In this study, the researcher employs a literature evaluation method to examine the key criteria influencing green building practices. This involves a comprehensive review of relevant sources, including academic journals, websites, and previous research papers, to collect insights and identify factors that affect green building practices.

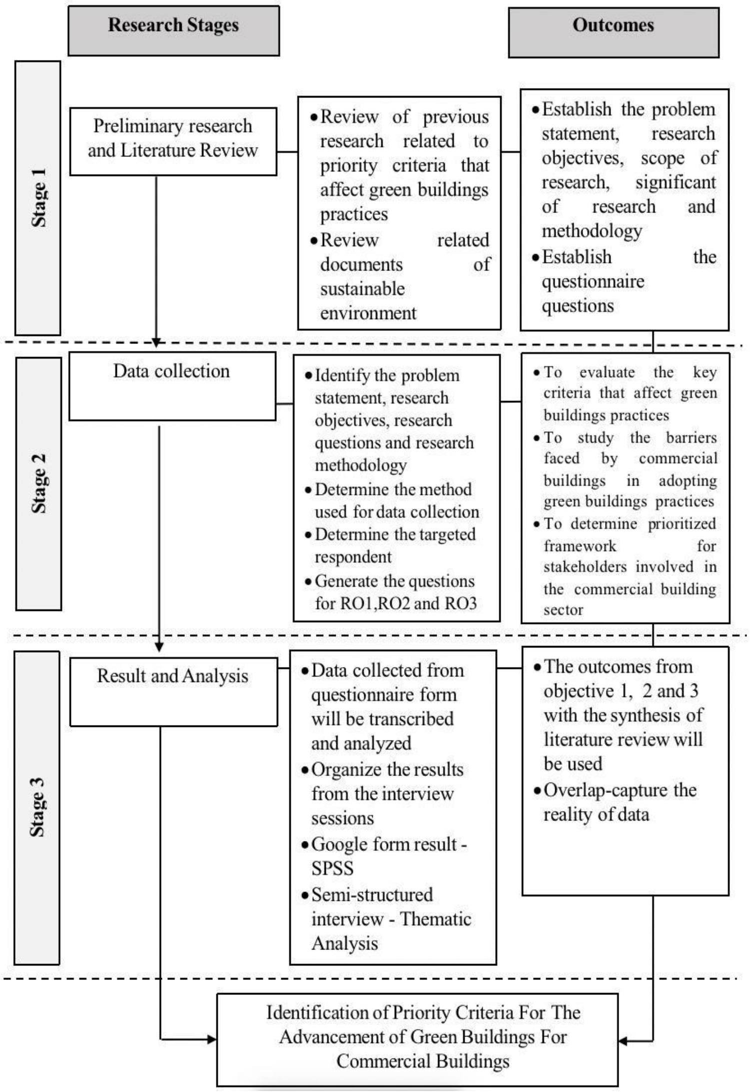

Figure 4: Research process for identification of priority criteria for advancing green buildings for commercial buildings.

2.3. Questionnaire Development

Questionnaires (see Table 2) in the form of an online survey are conducted to gather primary data regarding priority criteria that affect the effectiveness of the green building's practices. Closed-ended questions will be used for all the questions on the list. The questionnaire for this study was designed based on the literature evaluation of the existing research paper. The questionnaire for this research comprises two sections, each designed to achieve the research objectives. Section A of the online survey gathers demographic information from the respondents, including details such as name, gender, race, and years of work experience. On the other hand, section B consists of 4 questions that present a few criteria related to the green building projects. Respondents must rank the requirements based on their past experiences regarding the green building's practices. To facilitate this, a Likert scale ranging from 1 to 5 is employed; scale 1-strongly disagree, scale 2-disagree, scale 3-neutral, scale 4-agree, and scale 5-strongly agree. In addition, if they felt it was essential, the respondents were free to add additional criteria to the list. One commonly used method for this research is probability sampling, where every individual in the population has a known and equal chance of being selected. 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 various 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 how different criteria contribute to the effectiveness of green practices in commercial buildings.

Table 2: Questions and Scale Use.

Questions and Scale Use
Section A - Demographic 1. Age 2. Gender 3. Race 4. Level of Education 5. Profession in the Construction Field **6.** Years of Work Experience
Section B **B1: Which green building practices have you implemented or seen implemented in commercial buildings?** 1. Energy-efficient lighting (LEDs) 2. Solar Panels 3. Energy Management Systems 4. Water conservation system (low-flow, fixtures, rainwater harvesting) Sustainable materials (recycled, low-emission.
B2: In your experience, which of the following has the most significant impact on the effectiveness of green building practices in commercial buildings? 1. Effective waste management 2. Minimising carbon emissions 3. Innovative production and design 4. Energy Efficiency 5. Occupational Safety 6. Sound insulation 7. Renewable Energy Usage 8. Sustainable water management 9. Transportation 10. Education and culture 11. Quality of indoor space 12. Environmental quality 13. Social sustainability Other (Please Specify)
B3: Which of the following will affect the priorities of performance criteria in adopting green building practices in commercial buildings? 1. Obligations from the state development authorities/ Government planning approvals 2. Owner / Developer's choice 3. Investor requirement/ positioning with investors (e.g. Green Bonds) 4. Developer market position 5. Life cycle cost/Long-term savings 6. Design team advocating 7. Incentives by the state/ country

8. Tenants/ Potential purchaser/ client/ end-user requirement Other (Please Specify)
B4: What are the regional factors affecting the priorities of performance criteria in adopting green building practices in commercial buildings? 1. Climate 2. Regulations 3. Natural resource availability 4. Building product availability 5. Maturity and innovation in construction methods 6. Regional Economy 7. Knowledge and awareness of sustainability Other (Please Specify)

3. Results

3.1. Data Analysis

The responses from online surveys will be systematically grouped, categorised, and organised into themes relevant to the research objectives. **Statistical Product for the Services Solutions (SPSS)** software will be applied to evaluate the data, as it offers efficient data management capabilities. An ordinal scale, also known as a rank-order scale, is used to arrange the responses in order, from highest to lowest. However, it does not measure the exact difference between each rank—it simply shows the order of preference or priority. Therefore, a list of priority criteria that influence the effectiveness of green building practices will be provided.

3.2. Green building materials selection

Green building materials selection for sustainable buildings involves a comprehensive approach that considers environmental, economic, and social factors to reduce the ecological footprint of construction and ensure long-term sustainability [26-49]. The process emphasizes resource efficiency, focusing on materials that are renewable, recyclable, and locally sourced, thereby minimizing energy consumption and reducing greenhouse gas emissions associated with transportation; it also incorporates low-impact materials that are produced with minimal energy use and non-toxic processes, further contributing to a lower environmental impact throughout the material's life cycle, from extraction to disposal [50-65]. Materials such as bamboo, cork, and sustainably sourced wood are popular renewable options, offering excellent durability and minimal environmental disruption, while recycled materials like steel, glass, and reclaimed timber reduce the need for raw resource extraction and help divert waste from landfills [66]. Energy-efficient materials like high-performance insulation, thermal mass elements, and advanced glazing systems enhance a building's energy performance by reducing the need for artificial heating and cooling, thus lowering operational energy consumption over time, and this is complemented by the selection of materials with low embodied carbon, reducing the environmental burden of their manufacturing and transport [67,68]. Additionally, non-toxic and low-emission materials such as low-VOC paints, natural flooring options like linoleum, and clay or lime plasters contribute to healthier indoor air quality, critical for occupant well-being and productivity [69]. Green building material selection also prioritises long-term durability, reducing the need for frequent replacements and maintenance, lowering resource consumption over a building's life span. Beyond just individual building components, sustainable material selection contributes to broader environmental goals, such as reducing deforestation, conserving water, mitigating climate change, and fostering a circular economy in the construction industry by encouraging recycling and reusing materials. While the initial costs of green materials may be higher in some cases, the long-term financial benefits of energy savings, reduced maintenance costs, and increased property values can outweigh these costs, making green building materials a sound investment over time [70]. Furthermore, the growing demand for sustainable buildings has spurred innovation. New materials and technologies are continually being developed to enhance performance and minimise environmental impact, thus expanding the possibilities for sustainable construction [71]. Despite challenges such as limited availability in certain regions and a need for greater industry awareness, selecting green building materials is rapidly becoming a standard practice, driven by global initiatives, government incentives, and increasing consumer demand for environmentally responsible buildings [72-77]. Sustainable material selection also plays a role in promoting social equity by creating healthier, more comfortable living and working environments for occupants, thereby improving quality of life, reducing the risk of health issues related to indoor pollution, and providing long-term economic benefits through energy-efficient operations and reduced environmental harm [78]. As the building industry moves towards a more sustainable future, the selection of green materials is critical not only for reducing the carbon footprint of individual buildings but also for contributing to a larger, global effort to mitigate climate change, conserve natural resources, and create healthier communities for future generations [79]. This holistic approach to material selection in green building practices is essential for achieving the goals of sustainability, environmental stewardship, and resource conservation in the built environment, and it represents a key step toward transforming the construction industry into a more sustainable, resilient, and responsible sector.

4. Conclusions

Grasping the key factors influencing green building practices is essential for promoting sustainable development in commercial buildings. These buildings consume a significant amount of energy and contribute to environmental degradation, making it crucial to identify the most effective strategies for reducing their impact. By comprehending which criteria matter most, decision-makers—including policymakers, developers, and industry leaders—can implement solutions that improve energy efficiency and sustainability. Many businesses hesitate to adopt green practices due to cost concerns, lack of awareness, or regulatory barriers. This research helps uncover these challenges and provides actionable recommendations to overcome them. Using mixed-method data collection methods, such as qualitative and quantitative approaches, helps achieve the research objective by identifying key priority criteria that influence green building practices and promoting the adoption of the best green design strategies to create a more sustainable future for the commercial building sector.

Declaration of Conflict of Interest

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

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