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SUSTAINABLE CONSTRUCTION: GREEN BUILDING PRACTICES FOR GREEN INFRASTRUCTURE

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Abstract

This study aims to examine the implementation of green building practices in the framework of sustainable construction in infrastructure projects in Indonesia. Using a descriptive qualitative approach, data was collected through in-depth interviews, field observations, and document studies on several projects that have applied green building principles. The results show that the application of principles such as energy efficiency, water conservation, and the use of environmentally friendly materials has begun to be carried out, albeit with varying levels of application. Green buildings are proven to provide long-term economic and environmental benefits, including energy savings and reduced carbon emissions. However, challenges are still faced, such as a lack of understanding of industry players, limited experts, and uneven supporting policies. This study recommends strengthening policies, sustainable education, and the use of technology and regulatory incentives to accelerate the adoption of green buildings. The results of this study make an important contribution in encouraging the transformation of the construction sector towards a more sustainable and environmentally friendly direction.

Keywords: ***Green Building, Sustainable Construction, Infrastructure, Energy Efficiency, Green Development.***

INTRODUCTION

Infrastructure development has become one of the main indicators in the progress of a country. Through the construction of roads, bridges, buildings, and other public facilities, the state seeks to improve the quality of life of the people and accelerate economic growth (Siahay et al., 2023). However, behind the rapid development of infrastructure, there are serious consequences for the environment. Carbon emissions, excessive energy consumption, construction waste, and the reduction of green space are a small fraction of the negative impacts posed by the conventional construction sector (Fandeli, 2021). In recent decades, global concerns over the climate crisis and environmental degradation have prompted various parties to seek more environmentally friendly approaches to development (Surasmi et al., 2022). One of the solutions that has emerged is the concept of sustainable construction. Sustainable construction emphasizes the efficient use of resources, the reduction of environmental impact, and the creation of healthy and productive spaces for its inhabitants (Siregar, 2023). This concept considers not only technical, but also social, economic, and ecological aspects.

In the framework of sustainable construction, green building practices are one of the main approaches that are growing rapidly (Indah & Widyaningsih, 2025). Green buildings are buildings that are designed, constructed, and operated in a way that minimizes negative impacts on the environment and improves the quality of life of its inhabitants (Sudarwani, 2012). The concept of green buildings encompasses various aspects, such as energy efficiency, use of environmentally friendly materials, water conservation, natural lighting, and waste management. This shows that green building is not just about planting trees around buildings, but includes comprehensive systems and strategies. The application of green buildings is becoming increasingly relevant amid high energy consumption by the building sector which accounts for around 40% of total global energy. Thus, the transformation towards sustainable construction becomes an inevitable urgency. In addition, many countries have implemented green building standards and certifications such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and Greenship in Indonesia (Widiati, 2019).

This standard is a benchmark in assessing the extent to which a building meets the principles of sustainability. In Indonesia itself, the need for sustainable development is increasingly urgent given challenges such as rapid urbanization, climate change, and the increasing need for housing and infrastructure. Green buildings are a rational and strategic choice in facing this challenge. The Indonesian government through various policies and regulations has encouraged the development of green buildings. Several big cities such as Jakarta, Surabaya, and Bandung have begun to implement incentive policies for the construction of buildings that meet green standards (Chaerani & Firmansyah, 2024). However, the implementation of green buildings still faces a number of challenges, ranging from a lack of public awareness, limited funds, to a lack of experts in this field. Therefore, a more systematic and collaborative approach is needed between the government, the private sector, academia, and society. Sustainable construction development must also be accompanied by technological innovation. The use of digital technologies such as Building Information Modeling (BIM), Internet of Things (IoT), and smart materials is key in supporting efficiency and sustainability in construction projects (Sholeh, 2024).

Not only that, education and training for construction industry players is also an important aspect in expanding the application of green buildings (Widyawati, 2019). The engineering and architecture education curriculum needs to be adapted to be able to answer sustainability challenges. On a practical level, various case studies have shown that green buildings not only have a positive impact on the environment, but are also economically profitable (Marsini, 2025). Energy efficiency and reduced operational costs make green buildings a profitable long-term investment. People are increasingly aware of the importance of living in a healthy and comfortable environment. Factors such as indoor air quality, natural lighting, and comfortable temperatures are important considerations in choosing where to live or work. With increasing awareness of sustainability, the demand for green buildings is predicted to continue to grow. This opens up great opportunities for architects, engineers, and developers to innovate and contribute to creating environmentally friendly infrastructure. Sustainable construction also contributes to the achievement of the Sustainable Development Goals (SDGs), especially in the 11th and 13th points (Handling Climate Change).

Therefore, strengthening green building practices is not just a trend, but a necessity to answer current and future global challenges. Sustainable construction is a middle ground between development needs and environmental conservation. The research, development, and implementation of green building practices must continue to be encouraged as part of collective efforts in creating a better future. The infrastructure built today will determine the quality of life of future generations. In this context, the study of sustainable construction through green building practices is very relevant and important. This study aims to understand the principles, strategies, benefits, and challenges in implementing green buildings for the realization of environmentally friendly and sustainable infrastructure.

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RESEARCH METHODS

This research uses a qualitative approach with a descriptive method, which aims to describe in depth green building practices in the framework of sustainable construction (Agustianti et al., 2022). This approach was chosen because it is in accordance with the needs of research to explore the understanding, meaning, and dynamics that occur in the field, especially related to strategies, challenges, and impacts of the application of green building principles in infrastructure development. This research focuses on naturally occurring phenomena, so that data is collected directly from key sources in the field. The qualitative descriptive approach allows the researcher to present an in-depth narrative of green building practices applied in various construction projects, both public and private, as well as to understand the various factors that influence their success or failure. The selection of research locations is carried out purposively, namely based on the criteria of buildings or infrastructure projects that have applied green building principles in real terms. The locations used as the object of research include several office buildings, shopping centers, and public infrastructure projects that have received green certification such as Greenship from the Green Building Council Indonesia (GBCI) or other relevant standards.

The main data sources in this study consist of primary data and secondary data. Primary data was obtained through in-depth interviews with informants who have direct involvement in the planning, implementation, and supervision of green buildings. The informants include architects, contractors, developers, environmental consultants, as well as representatives from certification bodies (Rachmawati, 2017). The interview technique is carried out in a semi-structured manner to remain flexible but still directed according to the focus of the research. In addition to interviews, participatory observations were conducted at the project site to understand first-hand the practice and implementation of green buildings. The researcher recorded the physical condition of the building, the technology used, and the behavior patterns of the space users. These observations are important to complement the data from the interviews as well as to validate the suitability between concepts and practices in the field.

Secondary data was obtained through document studies that included project reports, planning documents, green building technical guidelines, government regulations, and publications from relevant institutions. These documents are used to strengthen the analysis as well as compare the applicable standards with the actual implementation in the field. The data analysis technique used in this study is thematic analysis. After all the data was collected, the researcher transcribed the interview, encoded the data, and grouped the data into relevant themes. This process is carried out inductively, namely by letting the data form certain patterns and meanings which are then analyzed in depth (Miles & Huberman, 1992). The validity of the data is maintained through triangulation techniques, namely by comparing data from various sources and methods. Triangulation was carried out between interview data, observations, and written documents. Thus, the accuracy and reliability of research findings can be improved.

In addition, the researcher also conducts member checking by asking for confirmation from the informant on the results of the interpretation of the data that has been analyzed. This aims to ensure that the findings obtained reflect the reality in the field and not just based on the researchers' assumptions. Research ethics are strictly maintained in the data collection process. Researchers ensure that all informants give consent to be interviewed and that their identities are kept confidential. The data obtained is used for research purposes only and is presented anonymously. Overall, this research method is designed to provide a complete and comprehensive picture of green building practices in sustainable construction. Through a qualitative approach, this research seeks to uncover the dynamics of the application of the concept of sustainability in the construction world, as well as present practical insights that can be a reference for policy makers, industry players, and academics in related fields.

RESULTS OF RESEARCH AND DISCUSSION

1. Application of Green Building Principles in Infrastructure Projects

The results of observations and interviews show that most of the infrastructure projects certified as green buildings have implemented basic principles such as energy efficiency, water conservation, the use of environmentally friendly materials, and waste management. Greenship certified buildings, for example, generally implement natural lighting systems, energy-efficient cooling technology, and the use of recycled water for irrigation and toilets. However, the rate of adoption varies depending on the scale of the project, the background of the project owner, and the geographical location. Projects in large cities are more likely to adopt a high-tech approach, while projects in suburban areas rely on a simple but still effective approach.

Table 1. Level of Implementation of Green Building Principles in Three Selected Projects

Green Building Principles	Project A (Government Building)	Project B (Commercial Mall)	Project C (Private Campus)
Energy Efficiency	Tall	Keep	Tall
Water Conservation	Keep	Tall	Tall
Eco-Friendly Materials	Tall	Low	Keep
Construction Waste Management	Keep	Keep	Tall
Utilization of Renewable Energy	Low	Keep	Keep

The findings of the study show that the application of green building principles has been carried out in stages in several projects, with a focus on energy efficiency, water conservation, and waste management. This is in line with the sustainable construction theory put forward by (Kibert, 2016), which states that sustainable buildings must maximize resource efficiency throughout their life cycle, from design to demolition. In the Indonesian context, the Greenship standard developed by the Green Building Council Indonesia (GBCI) is an important reference. Projects that obtain this certification demonstrate a commitment to the application of these principles. However, variations in the level of implementation between projects indicate the need for more structured policies and more equitable technical education. The application of natural lighting technology, energy-efficient cooling systems, as well as the use of local and recycled materials shows that the concept of passive and active design has begun to be adopted. This

is in accordance with the principles of ecological design that emphasize the adaptation of buildings to the local climate, as explained by (Vale & Vale, 1991).

2. Economic and Environmental Benefits of Green Buildings

The results of interviews with project managers show that green buildings provide long-term economic benefits through energy and water savings. While the initial cost of building green buildings tends to be higher, the reduction in electricity and water bills and lower maintenance costs make this investment more profitable in the long run. From an environmental perspective, the implementation of green buildings contributes to reducing carbon emissions and environmental pollution. This is observed from the reduction in the volume of construction waste and the decrease in energy consumption in air conditioning and lighting systems. This information is reinforced by the project's internal documentation which shows a reduction in energy consumption of 25–35% per year compared to conventional buildings. One of the important aspects found in this study is the long-term benefits of green buildings, both economically and environmentally. The results of this study support the views of (Force, 2003), which confirms that although green buildings have slightly higher initial costs, operational cost savings, increased productivity, as well as health benefits for space users will provide long-term benefits. From an environmental perspective, the reduction in energy and water consumption, as well as the reduction of greenhouse gas emissions, show that green buildings contribute directly to climate change mitigation. This is in line with the triple bottom line concept of (Elkington & Rowlands, 1999), which states that sustainability should be viewed from three aspects: profit, planet, and people. The findings regarding the operational efficiency and property value enhancement of green buildings are also consistent with international studies such as those conducted by (Construction, 2013), which reports that 54% of green building project owners record a faster return on investment than conventional buildings.

3. Challenges in the Implementation of Green Buildings

While the benefits of green buildings are clear, there are a number of challenges that hinder its widespread implementation. One of the main challenges is the lack of understanding and awareness among developers and the general public. Many project owners still view the concept of green buildings as an additional cost, not an investment. In addition, the limitation of experts and consultants who understand green building standards is an obstacle in itself. This has led to many projects not being able to achieve maximum certification despite having tried to implement some sustainability principles. Regulations that are not yet fully binding nationally are also an inhibiting factor. Although some local governments have provided incentives in the form of tax breaks or ease of licensing, these policies have not been comprehensive and have not been consistently implemented in all regions. Although the benefits of green buildings have been proven, the study also found various obstacles in its implementation. Lack of understanding and awareness among construction industry players is the main obstacle. This is in accordance with the findings (Zuo & Zhao, 2014), stating that social and cultural barriers are one of the biggest challenges in the implementation of green buildings in developing countries. The lack of experts who understand the concept of sustainable design and the lack of consistency of regulations are important issues. In the theory of diffusion of innovation by (Rogers, 2003), the acceptance of innovation is greatly influenced by the perception of its complexity and benefits. If green buildings are perceived as expensive and difficult to implement, then the adoption process will be slow. The lack of strong incentives from the government and weak oversight systems have also slowed progress. Therefore, the top-down approach (regulation) needs to be combined with a bottom-up approach (community and professional participation) to expand the systemic application of green buildings.

4. Strategies and Recommendations for Improving Green Building Practices

From the field findings, a number of strategies emerged that are considered effective to improve green building practices in Indonesia. First, collaboration between the government, private sector, and educational institutions needs to be increased to strengthen education and training related to green buildings. Second, the provision of financial incentives for green building developers needs to be expanded to attract more industry players. Third, digital technologies such as Building Information Modeling (BIM) can be used to design building systems that are efficient and easy to monitor in the long term. Fourth, increased regulation and supervision of construction projects must be carried out so that sustainability principles are not only a formality, but actually implemented in the field. Through these strategies, it is hoped that infrastructure development in Indonesia can further lead to an environmentally friendly and sustainable approach. Based on the results of the research, the strategy to increase the implementation of green buildings must include regulative, educational, and technological aspects. A collaborative approach between government, academia, and the private sector is an absolute requirement in realizing a sustainable construction ecosystem. This view corresponds to the triple helix model of the (Etzkowitz & Leydesdorff, 2000), which emphasizes the importance of synergy between the three main actors in the innovation process. The use of

technology such as Building Information Modeling (BIM) can speed up the design and supervision process of green buildings efficiently. BIM enables the analysis of building performance from the planning stage, making it easier to identify potential energy efficiency and waste reduction. In addition, policy revisions and incentives such as tax reductions, accelerated permits, and green project awards need to be expanded so that industry players have stronger motivation. Public education is also a key factor in increasing the demand for healthy, efficient, and environmentally friendly spaces.

CONCLUSION

This research shows that green building practices as part of sustainable construction are starting to experience positive development in Indonesia, even though the implementation is not evenly distributed. The application of green building principles such as energy efficiency, water conservation, use of environmentally friendly materials, and waste management has been applied to several infrastructure projects, especially those located in urban areas and have obtained certifications such as Greenship. This finding proves the commitment of some industry players to more environmentally friendly development. The benefits of green buildings are proven to not only have an impact on environmental preservation, but also provide long-term economic benefits. Energy savings, water efficiency, and improved comfort and health of residents are added values of this concept. In other words, green buildings support the principle of triple bottom line that includes profit, planet, and people in a balanced manner. However, the challenges in its implementation are still quite large.

The lack of public understanding, limited experts, and regulations that have not been integrated nationally are the main obstacles. The lack of incentives and policy support has also led many construction actors to be hesitant to invest in a green approach. This shows the importance of strengthening policies, education, and cross-sector collaboration so that the implementation of green buildings is not sporadic, but systematic and sustainable. Suggested improvement strategies include strengthening human resource capacity, regulatory incentives, and the use of technologies such as BIM to support more efficient planning and monitoring processes. Collaboration between the government, the private sector, and academia is indispensable to create a strong and purposeful sustainable construction ecosystem. Thus, sustainable construction through green building practices is not just a trend, but a real need to address the environmental challenges and urbanization of the future. Success in driving this transformation will be an important foundation for the creation of an environmentally friendly, efficient, and sustainable infrastructure in Indonesia.

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