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THE ROLE OF INFRASTRUCTURE IN GREEN BUILDING DEVELOPMENT IN ASIA AND THE WORLD: A COMPARATIVE STUDY OF FIVE COUNTRIES

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ABSTRACT

Abstract: Green building is evolving in response to the need for sustainable infrastructure in different countries. Five international journals India, Malaysia, China, Kazakhstan, and green building optimization globally show that the success of green building implementation is heavily influenced by the country's infrastructure capacity, including energy infrastructure, transportation, construction technology, policies, rating systems, and institutional support. This review analyzes the driving factors, obstacles, and strategic approaches in green building development based on the findings of the five journals. The results of the study show that countries with strong infrastructure are better able to implement the concept of green building consistently, while countries with limited infrastructure face material, technological, financing, and institutional barriers. The integration between infrastructure development and green building is the key to success towards environmental sustainability. Therefore, strengthening clean energy systems, low-emission transportation networks, efficient building technology, and comprehensive regulations are the main recommendations to encourage the implementation of green building in the future.

Keywords: Green Building 1; infrastructure 2; Asia 3; Building 4

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A. BACKGROUND

Green building is a development approach that emphasizes energy efficiency, sustainable resource utilization, waste management, and improving the quality of the environment in buildings. However, in its implementation, (Darko & Chan, 2016) *green building* cannot stand alone. All of its functions depend on the readiness of national infrastructure, such as energy, transportation, water and sanitation, *waste management*, to digital technology and government policies. In other words, (Sun et al., 2019) *green building* is an integral part of a country's sustainable infrastructure development strategy, the success of which is determined by the ability of the national infrastructure system to provide technology, regulations and resources that support sustainable construction practices.

Green buildings according to are buildings that have high performance and have minimal impact on the environment and human health written by . Environmental protection is related to the natural environment and the built

environment. One of the challenges of global development is climate change caused by Greenhouse Gas (GHG) emissions To minimize negative impacts on buildings, three basic processes are needed: 1) building lifecycle planning, 2) efficient use of resources, and 3) waste and environmental pollution reduction written by (Hong Kong Green Building Council (HKGBC) (2015) in . (Yudelson, 2007) (Darko & Chan, 2016) (Zainul Abidin Nazirah, 2010) (Barri, 2024). (Darko & Chan, 2016))

The journal "Development of a Green Building Sustainability Model for India" reveals that the key to the success of green building in India is not only building design innovation, but also the connection with energy infrastructure and government policies. The sustainability model offered shows that governments hold the strongest role in building the necessary regulatory systems, incentives, and infrastructure networks. The demand for green buildings is driven not only by market demand and public interest, but also by the full support of government regulations on green policies and properties (Sharma, 2018) (Barri, 2024).

Meanwhile, the journal "Barriers in Developing Green Buildings in Malaysia" confirms that the biggest obstacle to green building development is the lack of supporting infrastructure. For example, an energy system that still relies on fossil sources hinders the energy efficiency of buildings. In addition, the limitations of green material infrastructure cause construction costs to increase, so developers are reluctant to implement the concept. (El Qorina Safitri et al., 2022) (Samari et al., 2013)

The journal from China highlights the role of the green building assessment system as part of the national policy infrastructure. The Chinese government has established strict regulations and implemented the Green Building Evaluation Label (GBEL). Strong legislative infrastructure allows China to accelerate the adoption of green building technologies. Furthermore, the Kazakhstan journal emphasizes that countries with high dependence on fossil energy and weak economic infrastructure face significant obstacles in carrying out green development. Lack of experts, technological limitations, and weak material supply chains are evidence that infrastructure plays a fundamental role. (Shen & Faure, 2021)

In a global context, the journal "Towards Optimum Integrated Green Building Design Assessment" provides an overview that green buildings can only achieve optimal performance when the infrastructure systems that support them work in an integrated manner, such as efficient power grids, low-carbon transportation, smart building digital technologies, and modern water and waste management. (Lai et al., 2023)

Thus, the background of these five journals leads to one conclusion: Green building is not just a construction product, but part of a broader sustainable infrastructure ecosystem.

B. IMPLEMENTATION METHOD

The implementation methods in the five journals used show the approach to green building development that is closely related to the readiness of

infrastructure and institutional capacity of a country. Green buildings or often referred to as ecological buildings, low-carbon buildings or sustainable buildings refer to buildings that maximize resource conservation, protect the environment and reduce pollution (Dong & Ma, 2025).

In India, the sustainability model is used as a policy based on the foundation of implementation, so the method focuses heavily on regulatory analysis, government instruments, and the integration of green buildings in urban planning. To maintain optimal green building performance, there needs to be a real contribution from all levels of society and the role of the government as the most important factor in encouraging green initiatives ((Ling et al., 2015) in (Sharma, 2018) the country.

In Malaysia, its implementation is by identifying technical and structural obstacles that hinder the implementation of green building. By conducting a survey aimed at construction stakeholders, this study maps challenges such as limited green materials, efficient construction technology, and high costs. The focus is on constraint analysis that aims to formulate a more realistic development strategy that is in line with Malaysia's infrastructure conditions.

Then in China, the method used is oriented towards strengthening the national evaluation system through GBEL with a focus on research to assess the effectiveness of the rating system and mandatory government policies in encouraging the adoption of green technology. This approach emphasizes the implementation of IoT-based energy, as well as the capacity of the environmentally friendly materials industry. So that the implementation method in China is an example of an integrative model that combines aspects of policy, technology and industrial scale.

Meanwhile, in Kazakhstan, an energy infrastructure and national economic capacity assessment approach is used. By analyzing fossil energy dependence, lack of experts, and lack of *supply chain*, this study assesses the extent to which the country can adopt green buildings. In this study, the implementation is highlighted in the evaluation of real conditions in the field, so that the main goal is to identify the gap between policy intentions and actual infrastructure capacity.

So that from these studies, the implementation method is based on the integration of infrastructure systems that include energy, transportation, water, waste, and digital technology. Thus, this study provides an overview that the success of green building implementation can only be achieved if supporting infrastructure elements work in an integrated manner. This method shows that green building is not just an innovation at the building design level, but an implementation process that requires the synchronization of the national system.

An analysis of green building research from 1990-2015 shows that developing countries such as China and Malaysia have contributed significantly to green building studies, both in the certification of green buildings, energy performance, and advanced technologies, although developed countries dominate the overall publications. This approach emphasizes the importance of adjusting implementation methods to local contexts, such as improving energy efficiency through rating systems and reducing fossil dependence, which can be a model for other countries such as Indonesia in overcoming infrastructure barriers. Thus, the integration of national policies and stakeholders are the key to the transition towards sustainable green building. (Darko & Chan, 2016) (Berawi et al., 2019)

The relevance of the research methods of the five journals that have been *reviewed* is in the context of analyzing factors that influence the development of green buildings in various developing countries, namely in the four journals that are *reviewed* using a quantitative approach based on a questionnaire survey to collect data from industry experts to be analyzed statistically with several analysis methods such as Exploratory Equation Analysis (EFA). Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM) to validate conceptual models and test hypotheses.

In the article written by the (Sharma, 2018) analyst using a questionnaire survey with the Likert period to collect data from 1000 respondents in India, then apply it to the EFA and CFA to verify constructs, and SEM is used to test inter-construct relationships such as *issues*, *challenges*, *governance*, and *sustainable development*. The relevance of this method can be seen in an article written by Chan 2018, which also used a questionnaire survey of experts in Ghana to identify green building barriers that were analyzed with descriptive statistics and factor rankings, which is like the approach in categorizing factors based on PESTEL. The use of PESTEL analysis is used to categorize external factors as a complement to internal factor analysis, which shows methodological consistency in using primary data from surveys to build predictive models of green building in countries such as India, Ghana and Turkey (Sharma, 2018) (Sharma, 2018).

From the explanation above, it can be said that the green building assessment system has been widely used by countries in the world, and it takes a lot of involvement and many roles to create sustainable green buildings (Berawi et al., 2019) . According to the green building, it is an effort to improve the efficiency of buildings by considering natural resources at the same time and improving human habitation during the life cycle of buildings. So that in planning green buildings, the concept of sustainability is needed by considering the

environmental, social, and economic value of the building to preserve human welfare for the future. (Cassidy, 2003) (Berawi et al., 2019)

C. RESULTS AND DISCUSSION

1. India: Sustainability Model and Policy Infrastructure

India puts the government at the center in the green building sustainability model. Policy infrastructure, fiscal incentives, and standards are the main drivers. In addition, green building requires stable energy infrastructure as well as integration with urban planning.

The Indian Journal of *the Green Building Sustainability Model (GBSM)* revealed that the implementation of green building is highly dependent on **national policy infrastructure**. The Indian government was appointed as the main actor who was able to strengthen incentive instruments, set mandatory standards, and build rating systems such as GRIHA and LEED India. This policy infrastructure serves as the main framework for all stakeholders.

In addition to policy, energy infrastructure plays a crucial role. In India, urbanization growth has not been kept pace by a clean and stable electricity grid. Therefore, green buildings are often unable to achieve maximum performance. GBSM emphasized that the development of renewable energy infrastructure such as solar rooftops, smart grid, and microgrid is a fundamental component for the success of green building.

Furthermore, green building in India requires integration with urban development strategies, including low-emission mass transportation, clean water networks, and waste management systems. The sustainability model proposed by this journal concludes that **green building is just one subsystem in the sustainable infrastructure superstructure** that must be built simultaneously by governments, the private sector, and regulatory agencies.

The results show that the green building sustainability model in India is successful due to the collaboration of the government, corporations, developers, buyers, and private entities, with the government as the main actor in developing a mixed strategy that achieves sustainable development. The discussion highlights that without the integration of renewable energy infrastructure, green building in India is difficult to achieve maximum efficiency, especially in dense urban areas. This model can be used as a reference for other developing countries, with an emphasis on the role of governments in building parallel infrastructure to support long-term sustainability. (Sharma, 2018)

2. Malaysia: Obstacles due to Weak Infrastructure

Malaysia faces obstacles such as high costs, lack of technology, and limitations on green materials. This shows that the success of green building is

highly dependent on the supply chain of materials, green construction technology, and funding—all of which are part of the country's infrastructure.

In the journal, it was shown that the most dominant obstacles in the adoption of green building came from **the weakness of technological, material, and economic infrastructure**. Malaysia does not yet have a mature green materials industry, so energy efficiency materials must be imported from abroad, leading to much higher prices. Weak supply chain infrastructure causes developers to be reluctant to adopt green technology because they do not find a stable supply of materials.

In terms of energy infrastructure, Malaysia is still heavily dependent on fossil-based energy. An undecentralized energy system and lack of support for renewable energy make it difficult for green buildings to achieve the expected energy efficiency.

In addition to technical, policy and financing infrastructure are also obstacles. Lack of government incentives, lack of green credit schemes, and regulatory uncertainty hinder the adoption of green buildings. Educational infrastructure such as training and certification has also not developed, resulting in a low understanding of construction professionals about green building principles. (Samari et al., 2013)

These results confirm that in Malaysia, green building is hampered not because of its concept or design, but because the national infrastructure ecosystem is not ready to support it. Malaysia's dependence on fossil energy and the lack of *supply chain* of green materials has led to an increase in costs, reducing the adoption of technologies such as BIPV and ventilation systems This study shows that excessive use of fossil energy will cause it to be difficult for green buildings to achieve maximum energy efficiency, even though the potential for renewable energy such as solar and wind is high. The implication of this method is that parallel infrastructure development such as (Lai et al., 2023). *smart grids* and green funding is needed to overcome these obstacles.

3. China: Strong Regulatory Infrastructure

Green building in China is growing very fast due to **its strong regulatory and technological infrastructure**. The Chinese government has made green building part of its national development strategy. Green Building Evaluation Label (GBEL) is a mandatory national rating instrument for public projects. China is an example of a country that is able to encourage green building through a very strong regulatory infrastructure, such as GBEL and mandatory policies for public projects. The technological infrastructure is also growing rapidly, enabling the use of low-emission materials and IoT-based energy consumption

monitoring. In addition, China has a huge green material industrial infrastructure, including factories that produce low-E glass, eco-friendly materials, and prefabricated construction technology. This production infrastructure makes the cost of green building lower than other countries. (Shen & Faure, 2021)

Rapid urbanization in China is also encouraging the development of smart cities that support green building. Mass transportation infrastructure, smart grids, IoT-based energy monitoring systems, and modern waste management make green buildings function optimally. This journal proves that green building in China is successful because the country builds **a complete and integrated supporting infrastructure**, including regulations, technology, supply chains, energy systems, and municipal administration.

This shows that the integration of technological infrastructure such as IoT and smart grids, as well as green material supply chains, allows green buildings to function optimally in the context of rapid urbanization. From the challenges of other countries that depend on fossil energy, it shows that China is succeeding because of its more advanced renewable energy infrastructure, so it can be a model for developing countries. With an emphasis on integrated regulatory and technological infrastructure, it is key to the success of green building in highly urbanized countries (Lai et al., 2023).

4. Kazakhstan: Dependence on Fossil Energy Infrastructure

The Kazakhstan Journal points out the most contrasting problems. Kazakhstan has a high dependence on fossil energy such as oil and coal. Energy infrastructure that does not support efficiency makes it difficult for green buildings to be implemented optimally. In addition, the policy infrastructure is not yet strong, and there is no national standard that clearly governs green building.

Economic infrastructure is also an obstacle. Green materials are hard to find, experts are scarce, and modern construction technology is rarely used. This shows that countries with undeveloped infrastructure conditions will face enormous obstacles in implementing green building even though the initial intentions and policies are available.

From the social side, education infrastructure and public awareness are also still low. This hampered market demand, making it difficult for the construction sector to justify the initial cost of green building. Overall, the Kazakhstan journal shows that green building cannot be effectively implemented in countries with minimal infrastructure—both physical and institutional. Kazakhstan needs to be strengthened in terms of policy and e-commerce

infrastructure to overcome the obstacles that occur, with a focus on the integration of technologies such as BIPV and ventilation systems (Assylbekov et al., 2021)

5. Global Perspective: Infrastructure Integration as Key

The global journal shows that green building is only optimal when its supporting infrastructure is integrated, such as:

- Energy infrastructure
  - Efficient power grid
  - Smart grid
  - Renewable energy
- Low-carbon transportation
  - Public transport
  - Pedestrian-friendly streets
  - Electric vehicle network
- Modern water and wastewater infrastructure
  - Water recycling
  - Sustainable drainage
  - Smart waste management
- Smart building digital technology
  - IOT management system
  - Sensor IOT
  - Energy consumption monitoring
- Consistent technical regulations
  - Rating system
  - Regular construction.

The results of the review of this journal show that green building in Southeast Asia is only optimal with the integration of infrastructure such as regulations, renewable energy, and the supply chain of green materials, with the potential for renewable energy reaching 15% of the total energy This discussion reveals that without supporting infrastructure, green building will fail to achieve sustainability like Kazakhstan which is hampered due to fossil dependence. In India, the sustainability model emphasizes (Lai et al., 2023). (Assylbekov et al., 2021) *stakeholder* collaboration to develop a strategy-mix that achieves *sustainable development* (Sharma, 2018)

Without these elements, green buildings only function as an architectural concept, not a sustainability system. So, this article concludes that national infrastructure development must run in parallel with green building development so that both can create an efficient, safe, and low-emission urban

environment. A developing country needs to build parallel infrastructure to support green building, with a focus on renewable energy and national governance to achieve a low-emission urban environment. Overall, the discussion of these five journals emphasizes that the key to the success of green building is infrastructure integration.

D. CONCLUSIONS AND RECOMMENDATIONS

A comparative study of five international journals shows that the implementation of *green building* cannot be separated from the readiness of national infrastructure. Countries such as China and India have higher success because they are supported by strong policy infrastructure, technology and green materials industries. On the other hand, countries such as Malaysia and Kazakhstan still face major obstacles due to limited *supply chains*, construction technology, and low-carbon energy systems. The global perspective also emphasizes that *green buildings* can only function optimally when supported by the integration of energy, transportation, water, waste and consistent national regulations.

Based on the analysis of five journals, it can be concluded that the success of green building is largely determined by the quality of a country's infrastructure. Countries with strong infrastructure both in terms of energy, technology, regulation, and *supply chain* are better able to adopt and sustain green development. In contrast, countries with limited infrastructure face a variety of technical, economic, and institutional barriers.

This further shows that the successful implementation of green building can be achieved when supported by strong infrastructure integration, clean energy, low-carbon transportation, modern water and waste management, digital technology, and a consistent evaluation system. Without proper integration, green buildings are only limited to architectural concepts, not sustainability systems that are able to have a real environmental impact.

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