The Potential of Green Buildings: a Solution to Reduce Global Warming

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Abstract. This study was conducted to investigate the development of green buildings as a means of mitigating global warming, and was accompanied by innovations in green building designs, specifically for ready-to-live-in houses, aimed at reducing global warming. This study was conducted by identifying global warming problems, analyzing Scopus metadata, and utilizing data analysis tools such as VOS Viewer and Biblioshiny, as well as designing innovative solutions with green building plans specifically for residential buildings. The house design was created with an analogy of a 10m x 15m land area for a 2-story building. The study's results stated that the designed house was suitable as a reference for green buildings that could help reduce global warming. The concept of "green building" is closely related to global warming mitigation, as it involves "energy utilization" and "energy efficiency".

1 Introduction

Global warming has become a pressing environmental issue that has garnered special attention since the beginning of the 21st century. This is due to the significant increase in the Earth's average temperature resulting from human activities that have led to greenhouse gas emissions, particularly from the energy, industry, and transportation sectors. Furthermore, the Earth has become densely populated, resulting in the conversion of many forests to residential and industrial areas, which inevitably leads to the loss of natural land that serves as the Earth's lungs. On the other hand, natural factors do exist, but their impact is far less significant than the effects of human activities. Therefore, the impacts of global warming have become more frequent in the 21st century.

Unpredictable seasons accompanied by extreme weather are among the impacts of global warming. Furthermore, rising sea levels and environmental degradation are also threats that humans must be wary of, as they could lead to prolonged natural disasters that are ultimately the result of human activity. This can be prevented through increased human awareness and support for sustainable solutions in all sectors, including the construction and housing industries. Furthermore, Climate Watch data from 2022 shows that 76% of global greenhouse gas emissions are due to energy use [1].

Responding to the global challenge of greenhouse gas emissions, a transformation of the concept of "green building" and environmentally friendly construction is necessary to mitigate the impact of global warming. This transformation of the concept of "green building" can begin in the human residential environment by reducing energy use within the home. The concept of “green building” in homes can minimize greenhouse gas emissions [2]. Furthermore, the concept of "green building" emphasizes the use of environmentally friendly materials, natural lighting and ventilation, and a reduced carbon footprint throughout its entire life cycle [3]. This is the principle of the "green building" concept, ensuring that ready-to-move-in homes can optimize sunlight, have natural air circulation, utilize rainwater harvesting, and implement effective waste management systems. Therefore, the concept of "green building" for homes can contribute significantly to environmental sustainability by reducing energy use, as shown in Figure 1.

Sector	Main Category	tCO2e (2022)	% of Total
Electricity & Heat	Energy	16.7B	33%
Transportation	Energy	8.2B	16%
Manufacturing & Construction	Energy	6.3B	13%
Residential & Commercial	Energy	3.2B	6%
Fugitive Emissions	Energy	3.1B	6%
Military Fuel Use	Energy	603M	1%
Agriculture	Agriculture & Forestry	5.9B	12%
Land-Use Change & Forestry	Agriculture & Forestry	1.3B	3%
Industrial Processes	Industrial	3.2B	6%
Waste	Waste	1.7B	3%
Total	N/A	50.1B	N/A

Fig. 1. Global greenhouse gas emission sector ranking [1].

Figure 1 shows that 24% of excess greenhouse gas emissions come from agriculture, land-use change and forestry, industrial processes, and waste. Meanwhile, 76% of the emissions come from the combustion of fossil fuels, such as coal, oil, and natural gas. The combustion of these fuel accounts for 33% of the electricity and heat needed by humans for daily activities, 16% for driving, 13% for construction and manufacturing, 6% for residential and business buildings, 6% of the energy that could be generated by human activities is wasted due to leaks, such as drilling leaks or methane leaks from pipes or mining, and 1% for military fuel use, such as during military training operations. Therefore, awareness of global warming must begin within the home environment to foster habits of support for efforts to reduce global warming in every sector contributing to greenhouse gas emissions.

The concept of "green building" in home construction is a form of awareness of global warming that should become a new policy. This not only addresses the negative impacts of global warming but also encourages a lifestyle that aligns with environmental, economic, and social sustainability. In this context, building environmentally friendly, ready-to-move-in homes is a crucial innovation for creating a sustainable future for future generations. This article will describe, through metadata and innovations in ready-to-move-in home designs, with the 'green building' concept, that can reduce global warming by answering the following research problem formulation:

1. How the development of green buildings can reduce global warming?
2. How to design a green building of house to reduce global warming?

2 Methodology

This study uses a bibliometric data analysis to map the need for "green buildings" to reduce global warming based on Scopus-indexed publications from 2014 to 2024. The bibliometric analysis method is used in this study because it is effective in identifying research trends and evaluating the development of a research topic based on publication metadata [4]. The results of the bibliometric analysis can be used to identify articles that serve as a basis for research. This study aims to establish a basis for designing innovative solutions with a "green building" floor plan for a house. The flow of this research is shown in Figure 2. This research used the Scopus database with the keywords "green building" and "global warming." The publications found in the search were filtered to obtain 884 relevant documents for further bibliometric analysis. This is shown in Figure 3.

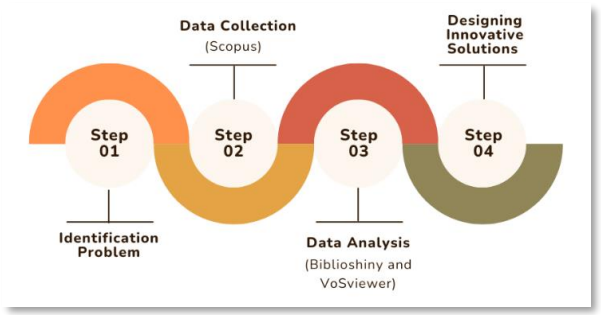

Fig. 2. Research flow chart

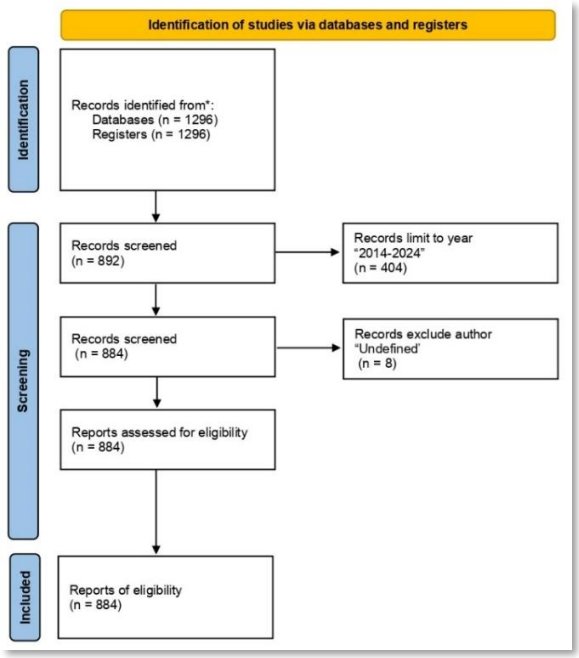

Fig. 3. Research stages of data collection.

3 Result and Discussion

3.1 Analysis development of green buildings can reduce global warming

A search of Scopus-indexed publications between 2014 and 2024 shows a significant increase in publications on "green buildings" related to "global warming" from 2021 to 2024. Between 2014 and 2018, publications on this topic were not a focus for global researchers because the number of publications in that period experienced inconsistent increases and decreases. From 2018 to 2020, publications on this topic initially experienced a fairly consistent increase. Between 2020 and 2021, the number of publications on this topic remained relatively constant. This is shown in Figure 4.

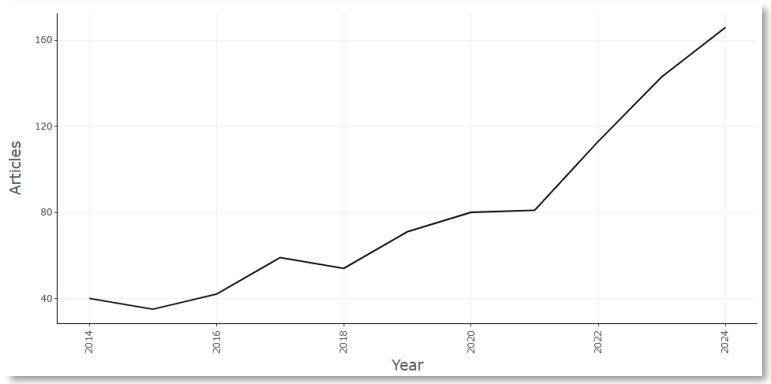

Fig. 4. Publications on this topic during 2014 – 2024.

The publication trend on "green building" associated with "global warming" indicates that the focus on mitigating global warming can be addressed through building design and construction materials. This can be seen from the highest frequency of keyword appearances in searches for this publication trend on global warming, which has a strong network of sustainable development, carbon dioxide, greenhouse gases, climate change, energy utilization, energy efficiency, and green building. Research on "green building" has been raised as one of the efforts to reduce global warming because it is related to environmentally friendly and energy-efficient building design. The relationship between the network of publication trends on this topic is shown in Figure 5.

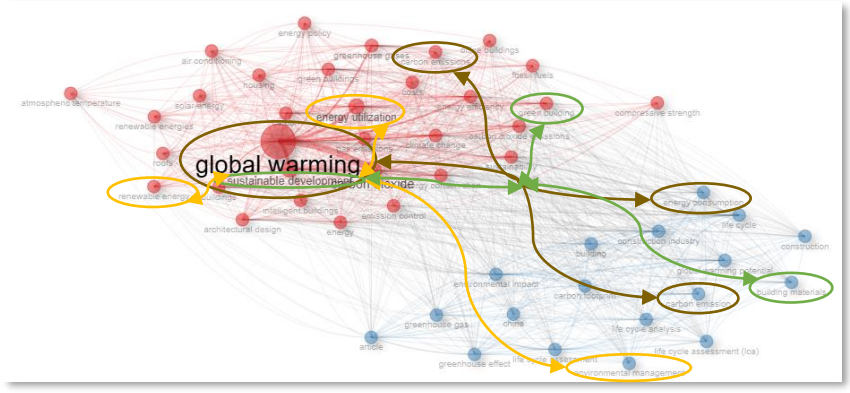

Fig. 5. Metadata of keyword co-occurrence network.

Figure 5 shows the trend network of Scopus-indexed publications with the keywords "green building" AND "global warming," which often relate to discussions of global warming. Discussions of global warming are related to the topics of carbon emissions and energy consumption (marked with brown highlights). On the other hand, publications with global warming topics are associated with mitigation topics such as energy utilization, renewable energy solutions, and environmental management (marked with yellow highlights). Furthermore, this mitigation is carried out by supporting sustainable development, which is also related to innovations from publications discussing green buildings and building materials (marked with green highlights).

Building materials need to be considered to support the achievement of green buildings, which have significant potential as a solution to mitigate global warming. Based on the co-occurrence analysis of ID=main keyword, DE=author keyword, and KW=All keywords combined from the automatic indexing results, it is evident that the most dominant keyword is “global warming”. Global warming is a key term that connects all related concepts to the idea of "green building". Green building publications on global warming are often associated with the keywords "energy utilization" and "energy efficiency". Therefore, green buildings are one solution to global warming mitigation. The visualization of keyword relationships is shown in Figure 6.

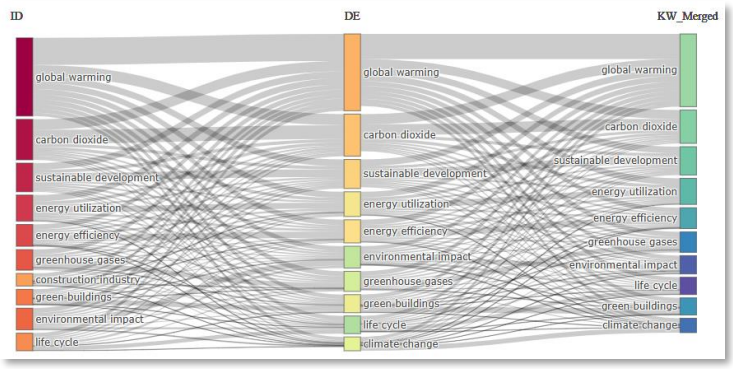

Fig. 6. Three-field plot diagram of keywords "green building" AND "global warming"

Figure 6 shows a three-field plot diagram of keywords showing strong correlations between the keywords global warming, carbon dioxide, sustainable development, energy efficiency, environmental impact, life cycle, and green buildings. This suggests that the direction of green building research indexed by Scopus has a connectivity that leads to energy-efficient development, architectural design, greenhouse gas emission mitigation, and global climate change control. Research by Shen et al. [5], data from respondents who have a concept of “green buildings” for residential buildings indicate that they agree that the building must pay attention to information on energy consumption and indoor environmental quality. This data is shown in Table 1.

Furthermore, according to bibliometric publications, the green building concept is now geared towards supporting sustainable development goals, with the application of life cycle assessments (LCAs). This has a comprehensive environmental impact from construction to building operation. Thus, green building construction integrates energy efficiency, the use of environmentally friendly materials, and carbon emission management, making green building design not merely an architectural innovation but also a tangible instrument in supporting the transition to low-carbon and climate-resilient development.

Table 1. Summary to consider in building performance.

Country	Building Types	Concent of Energy Consumption	Indoor Environmental Quality
Japan	Public and residential building	Heating/cooling hours; electricity/fuel/gas/oil consumption; hotwater/ steam/clean water consumption; annual primary energy consumption per average unit area Energy consumption (heating/cooling/ lighting/total); district heating/cogeneration consumption; equivalent energy demand Lighting/HVACsystems information; summer/ winter peak; rate structure; fuel/ electricity/regional energy use density and annual consumption	-
The EU	Public and residential building		-
The U.S.	Public, residential, and industrial building		Lighting; air distribution; heating; zonal heating; cooling; zonal cooling

Based on research by Qiufeng et al. [6], they summarize the evaluation results of several studies related to "green buildings" in several countries. This research aimed to assess the standards of the "green building" concept that had been implemented, and it helped inform the proposal of a "green building" design for ready-to-live-in houses. The summary of the evaluation results from Qiufeng et al.'s research, which served as the basis for the innovation of "green building" designs to mitigate global warming, is presented in Table 2.

Table 2. Summary for research evaluation of green buildings.

Author's Name of Research Sources	Year of Research	Evaluated Countries	Evaluation Focus	Things to Note
Olawumi and Chan [7]	2021	Nigeria	- Sustainable construction practices - Site and ecology - Energy	- Sustainable construction practices - Site and ecology - Energy - Water - Material and waste - Transportation - Indoor environmental quality - Building - management
Abdelalim and Abo.elsaud [8]	2019	United States	- Location and transportation - Sustainable Site	- Materials and resources - Location and transportation

Author's Name of Research Sources	Year of Research	Evaluated Countries	Evaluation Focus	Things to Note
				- Sustainable sites - Water efficiency - Energy and atmosphere - Indoor environmental quality - Innovation in design - Regional priority
Jiang et al. [9]	2018	China	- Land saving - Land Utilization	- Land saving and land utilization - Energy saving and energy resource utilization - Water saving and water resource utilization - Material saving and material resource utilization - Indoor air quality - Construction Management - Operation management
Ilhan and Yaman [10]	2016	United Kingdom	- Materials	- Management - Health and wellbeing - Energy - Transportation - Water - Materials - Waste - Land use - Ecology - Pollution

Based on "analysis development of green buildings can reduce global warming," the application of the concept of "green building" can be said to be a solution to mitigate global warming. This can also support sustainable development because the concept of "green building" requires the integration of environmental, social, and economic aspects to create a habitable building that is resistant to environmental risks in the future [11-12]. Integrated building design in a sustainable urban environment requires the creation of an environmentally friendly spatial system [13]. Furthermore, stated that supporting the SDGs program requires effective management to mitigate environmental risks, and it is crucial to implement energy efficiency measures in every sector to minimize the adverse environmental effects [14]. Therefore, the implementation of the concept of "green building" enables environmentally friendly architectural innovation and serves as a tangible manifestation of reducing global warming through energy efficiency and minimizing carbon emissions.

3.2 Design a green building of house to reduce global warming

The green building concept house design proposed in this study measures 15 meters x 10 meters. This size analogy optimizes energy efficiency, natural air circulation, and maximizes lighting. However, it can still serve as a reference for houses with smaller or larger land areas than the design presented in this study. The house design in this study uses the standards discussed in "Analysis of Green Building Development Can Reduce Global Warming."

The house design proposed in this study consists of two floors. Each floor features a green corner, indicating that plants are present to help maintain clean indoor air. Both the first and second floors are equipped with maximum lighting and air circulation thanks to sliding glass doors and windows installed three-quarters of the building's height. These doors and windows are used in every room of the house. The floor plan is also free of partitions, creating a spacious feel and preventing obstruction of light and air circulation.

The first floor serves as a public area, featuring the living room, dining room, kitchen, and garden, which helps maintain humidity. Access to the front garden, back garden, and side garden, complete with a swimming pool and fish pond, is not enclosed on the second floor. The second floor is designated as a private area, featuring bedrooms and a family gathering room, as well as a sports area. Unlike the first floor, which features numerous sliding glass doors, the second floors feature numerous windows equipped with ventilation. The second floor also features a rooftop garden for growing plants, while the first floor's garden primarily functions as an ornamental flower garden.

Fig. 7. 1st floor house plan design

Figure 7 shows a house design with a first-floor layout that minimizes energy consumption, reduces carbon emissions, and provides thermal comfort for its occupants. This makes it highly feasible to support solutions to reduce global warming because the house design is equipped with green corners and also utilizes glass partitions. The only partitions in the house plan are doors and windows because the house design is made to be integrated without walls. Thus, this house implements a green building because occupants can minimize the use of lights and air conditioning due to the extensive access to light from the glass doors

and windows. The house plan features a swimming pool located next to the house without a roof covering, allowing light to enter from the side. Similarly, the fish ponds located behind and to the side of the house also do not block out light.

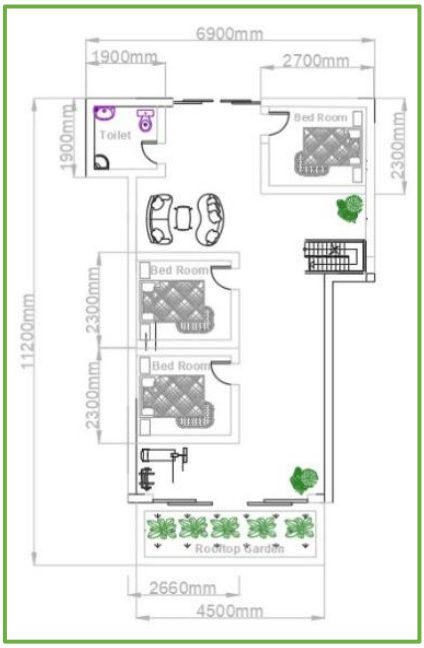

Fig. 8. 2nd floor house plan design

, a combination of these elements minimizes energy consumption, reduces carbon emissions, and provides thermal comfort for occupants. Figure 8 shows a house design that has a second-floor layout from figure 7. The second-floor plan is only a building above the main room of the first floor which is equipped with a rooftop garden on the balcony. Unlike the first floor, the second floor is equipped with three bedrooms, although like that the room on the second floor is also not separated by walls. The second floor is equipped with large windows so that the house building still has access to incoming light. In the front area before the rooftop, gym equipment is placed so that when residents exercise, they can still enjoy a fresh and cool atmosphere. Thus, design of first-floor layout and second-floor layout implements the green building as a solution to reduce global warming.

4 Conclusion

Publications with the keywords "green building" and "global warming" were analyzed in this study from 2014 to 2024, a period that coincided with a notable research trend from 2018 to 2024. Although the number of studies remained relatively constant from 2020 to 2021, it increased significantly from 2021 to 2024. The keyword "global warming" became the dominant keyword connecting all related publications to the concept of "green building". The concept of "green building" can be a solution to mitigating global warming because it supports reducing greenhouse gas emissions. This is because the concept of "green building" is closely related to "energy utilization" and "energy efficiency. Through the innovation of green building plans specifically designed for residential buildings in this study, it is suitable as a reference for green buildings that can help reduce global warming. The house design was created with an analogy of a 10m x 15m land area for a 2-story building. Further research is recommended to expand the scale of bibliometric data collection. This aims to gather more references

to strengthen green buildings. In addition, further research is also recommended to implement green buildings as a development to support other SDGs.

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