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Review Article

Impact of Green Building Implementation on Health and Well-being of Building Users in Indonesia

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Abstract

This research conducts a systematic literature review, adopting the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, to examine the impact of green building implementation on health and well-being of users in Indonesia. The aim is to systematically categorize and analyze both the positive and negative effects of green building practices on occupants while identifying specific challenges that influence occupant comfort and safety. After analyzing articles from 2018 to 2023, a total of 15 papers were identified as primary resources for this study. The research found that green buildings have both positive and negative impacts. Positive impacts include minimal air pollution, good natural lighting, cool natural ventilation, and reduced noise disturbance. There are negative impacts such as insufficient natural lighting and ventilation in some areas, high noise levels, and security issues. This research provides insights for improving green building concepts to better support public health and occupational safety. By considering these impacts, future building environments can be designed to be healthier and more conducive to promoting public health and well-being. Future research should address operational challenges by exploring hybrid systems that integrate natural and artificial elements for consistent comfort, along with innovative solutions for noise and wildlife control.

Keywords: Environmental health; green building; systematic literature review; well-being

1. Introduction

Green building is a development approach that aims to reduce negative impacts on the environment while improving the quality of life of its occupants (Yasinta et al., 2024). The World Green Building Council describes green buildings as structures that minimize or eliminate adverse effects and can generate positive effects on the climate and natural surroundings via their layout, construction, or operation (Zitars et al., 2021). Additionally, though it may be less commonly acknowledged, green buildings are designed to enhance human health by creating healthy indoor environments (Allen et al., 2015). In the context of climate-sensitive health risks in coastal environments, the application of green building concepts is becoming increasingly important (Arifin et al., 2019). By integrating environmentally friendly design and efficient technology, green buildings can help address the challenges of climate change and improve the health and well-being of people living in coastal areas (Arifin et al., 2019; Ijong, 2018). The term "green building" describes the process of creating, erecting, and maintaining structures in an ecologically conscious and sustainable way (Prasetia et al., 2022). This approach aims to minimize the environmental impact of buildings throughout their lifecycle, from planning and construction to operations and finally demolition or renovation (Bahaudin et al., 2014).

The main principles of green building include sustainable site selection, efficient use of water and energy, use of environmentally friendly materials, and management of indoor environmental quality. The implementation of green building principles addresses various environmental and health concerns. It encourages strategies such as passive design to enhance natural lighting and ventilation, reducing reliance on artificial lighting and Heating, Ventilation, Air-Conditioning (HVAC) systems (Altan et al., 2016; Ardyan et al., 2023). These strategies not only aim to improve energy efficiency but also contribute to creating a healthier indoor environment for building occupants. In Indonesia, several green building standards and certifications have been implemented, such as Greenship from the Green Building Council Indonesia (GBCI). Previous research shows that adopting green construction practices can enhance indoor air quality, lower exposure to dangerous, and enhance thermal and visual comfort. Some green buildings in Indonesia have successfully implemented green building principles, such as office buildings and public facilities (Zakiah, 2023). This case study demonstrates that the implementation of green buildings not only improves energy efficiency and environmental sustainability, but also provides significant health benefits for residents (Chaerani and Firmansyah, 2024). Workers in green-certified buildings had 26.4% higher cognitive function scores and 30% fewer sick building syndrome symptoms than workers in non-green-certified buildings, according to research done in five American cities. This suggests that the advantages of green certification extend beyond quantifiable indoor environmental quality factors (MacNaughton et al., 2017).

In addition to residential buildings, public infrastructure such as terminals applied to the concept of green building also has a significant impact on the environment and building users as in the research conducted Rachmalia et al (2023) which found that the effect of the position of building openings has a significant influence on natural ventilation and lighting in the building, but only areas close to the natural ventilation and lighting area can feel natural ventilation and the center of the building does not get it. In addition to having a positive impact on the health and comfort of building users, the application of the green building concept can also have negative effects. Research has shown that wide air ventilation openings can lead to increased noise from airplanes taking off, which requires service users to adapt to the situation. Additionally, these openings may allow the entry of wild animals, such as birds or bats. The high cost of building maintenance and the need for detailed, specialized upkeep further contribute to the long list of negative impacts associated with green building concepts (Cahyaningrum and Yudianto, 2023). A new body of evidence shows that green buildings provide a better indoor environment, with green buildings outperforming conventional buildings in a variety of areas, including neighborhood satisfaction, thermal comfort, views, aesthetic appeal, reduced HVAC noise intrusion, workplace image, sleep quality, mood, physical health, and lower levels of particulates in the air (Newsham et al., 2013). Previous studies on green building implementation have highlighted the positive and negative impacts on building users, these studies often focus on specific aspects such as air quality, daylighting and energy efficiency (Bahaudin et al., 2014; Altan et al., 2016; Ardyan et al., 2023).

As of June 2019, approximately 392 buildings in Indonesia had adopted the green building principles, covering a total area of about 25 million square meters. This figure stems from Jakarta's governor regulations on green buildings, which were established in 2012 (Sahid et al., 2021). While this represents progress in implementing green building standards, the scale of adoption remains relatively modest when compared to other countries such as Singapore, which has advanced more rapidly in this area (Sahid et al., 2020). However, the adoption of green building practices in Indonesia is expected to grow as more awareness and regulations are implemented across the country. Gaining further insight into the features of green buildings that are linked to different outcomes related to health, well-being, and productivity is necessary. Previous research abroad shows how psycho-environmental models of potential may serve as a theoretical foundation for explaining how green buildings affect specific people (Zitars et al., 2021). This literature study aims to systematically categorize and analyze the positive and negative impacts of green building implementation on the health and well-being of building users in Indonesia, providing a comprehensive understanding of how these practices influence occupant comfort and health,

ultimately contributing valuable insights to the ongoing discussion on sustainable building practices in the region. This method is commonly used to evaluate and synthesize research findings to inform practices, policies, further research, and to minimize research bias (Munn et al., 2018).

2. Methods

A systematic literature review is the method used in this research. This method aims to synthesize and evaluate relevant research findings on green building implementation and its impact on the health and well-being of building users in Indonesia. This approach allowed the researcher to identify, evaluate and reorganize the existing evidence from various relevant studies in this domain (Munn et al., 2018). This literature study method was chosen for its ability to provide a comprehensive and in-depth view of a complex research topic, such as the impact of green building on the health and well-being of building users in Indonesia. Thus, it is hoped that the results of this study can make a meaningful contribution to the development of knowledge and understanding in this field. The articles used came from publications from 2018 to 2023 and were obtained from various sources of national and international journals and proceedings that study buildings in Indonesia.

The article search was conducted using the Publish or Perish application, which utilizes the Google Scholar database with the keywords "influence," or "impact," or "effect," and "green building," and "health," and "well-being." The keywords used for searching articles were in the Indonesian language, which effectively captures the specific context and nuances related to green building and health in Indonesia. Utilizing Publish or Perish in conjunction with Google Scholar provides comprehensive coverage of diverse academic literature, including journals and theses, ensuring a broad range of citation metrics (Harzing, 2011). This free and user-friendly tool integrates seamlessly with Google Scholar for efficient data retrieval and analysis. Additionally, users can customize their searches and metrics to align with their specific research needs.

In this literature study, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method was adopted following Page et al. (2021) and adjusted to meet the study's specific needs and objectives, as illustrated in Figure 1. The study began by defining two key research questions: the first focused on the impacts of green building practices on the health and well-being of building users in Indonesia, and the second addressed the challenges faced in implementing green building practices that influence occupant comfort and safety.

A systematic literature search was conducted through various academic databases to identify relevant articles, including scientific journals, conferences, and related reports. Articles located through the search were then screened based on inclusion and exclusion criteria. The inclusion criteria prioritized relevance to the research topic, methodology used, and emphasis on green building's effects on the health and well-being of Indonesian building users. Exclusion criteria involved article characteristics such as citation frequency, data completeness, and removal of duplicates. Additional criteria for exclusion included document types (e.g., books and citation-only sources), origin from non-peer-reviewed university repositories in Indonesia, and articles missing essential details like abstracts, publication year, link sources, or publisher information.

Once selected, articles were evaluated in-depth to extract relevant information, such as key findings, research methods, and conclusions. Data from these articles were synthesized to create a detailed view of green building's positive and negative impacts. The synthesis also included the categorization of positive and negative impacts and an analysis of important trends or patterns.

Finally, the organized and synthesized information was systematically compiled into a research report, including an introduction with background, state-of-the-art overview, and research novelty. The report also provided an analysis of findings and conclusions that aligned with the research objectives.

3. Result and Discussion

The search results from the Publish or Perish application get a total of 209 documents from the database sourced from Google Scholar. Then the unqualified documents are grouped and removed, grouping into: 1. Citation; 2. Repository; 3. Without abstract; 4. Book; and 5. No Year/Source/Publisher, a total of 93 documents were removed and left a total of 114 documents. Furthermore, papers with unrelated titles and duplicates removed a total of 87 papers, leaving a total of 27 papers. Then exclude 9 papers because these papers contain the building design stage only, which means that the application of green building has not been felt by building users, leaving 18 papers. Eliminated 3 papers due to lack of data and there are unexpected duplicate papers, leaving 15 total papers that will be reviewed for content in accordance with the title and keywords as can be seen in Figure 1.

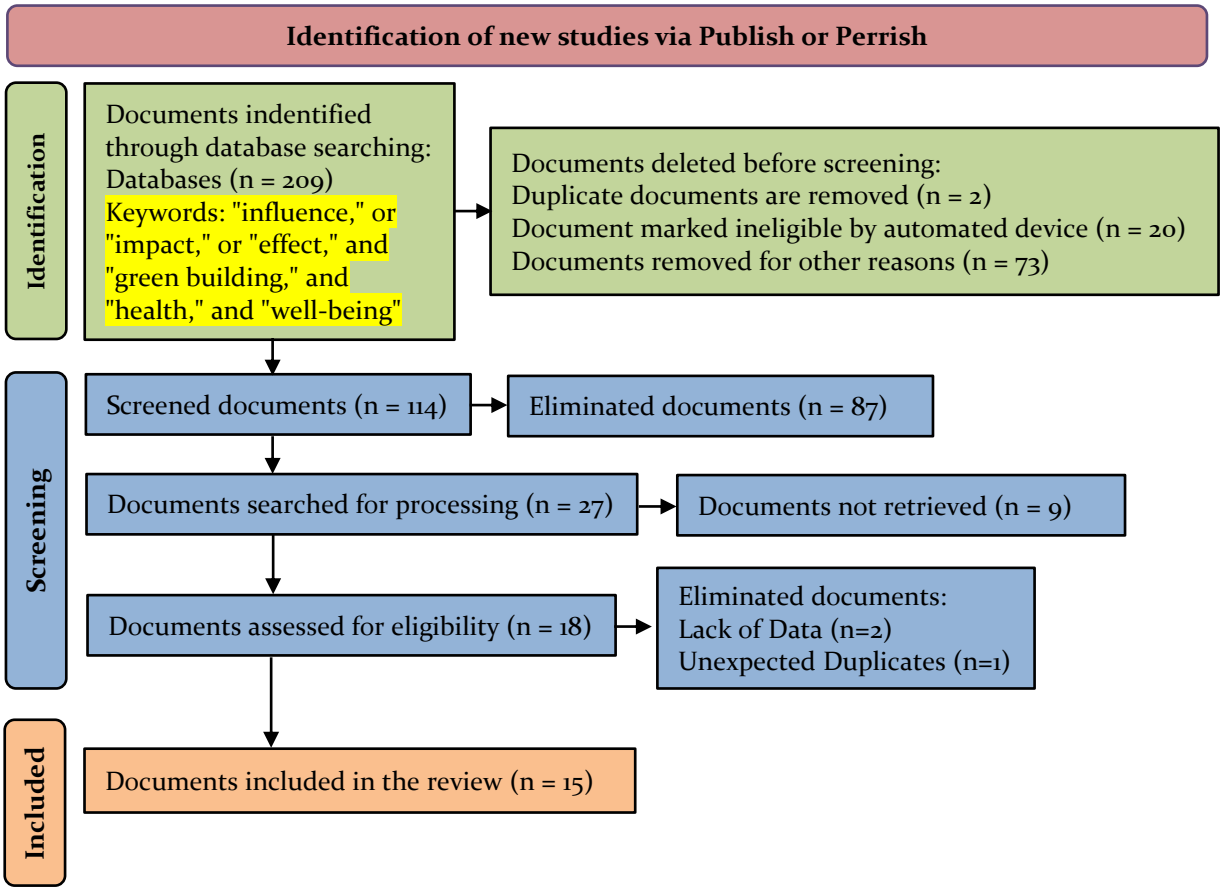

Figure 1. Process of selecting past articles

Table 1 below shows the characteristics and variations of the articles used in the literature study on the impact of green building implementation on the health and comfort of building users in Indonesia. The table includes the year of publication of the article as well as the research method used.

Table 1. Overview of selected articles

Characteristic	Variation	Amount	Journals	Proceedings
Year	2023	5	2	3
	2022	-	-	-
	2021	2	1	1
	2020	1	1	-
	2019	3	0	3
	2018	4	4	-

Characteristic	Variation	Amount	Journals	Proceedings
Research Methods	Quantitative	3		
	Qualitative	12		

The majority of these articles were published in 2023, as many as 5 articles, the research methods used were mostly qualitative approaches, as many as 12 articles, and 3 articles that used quantitative approaches. This shows the tendency of researchers to explore the impact of green building through qualitative methods in the Indonesian context. While it is acknowledged that proceedings are often considered lower-tier sources compared to peer-reviewed journals, they hold significant value in this research due to their timely presentation of cutting-edge studies and innovative solutions (Dejong, 2023), particularly in conferences focused on green building practices. In this field, many high-quality proceedings are produced from reputable international conferences that feature rigorous peer-review processes, showcasing critical findings and ongoing research. Furthermore, the specific proceedings selected for this study are from well-established and respected events, ensuring that the research presented is credible, relevant, and aligned with current developments in green building implementations. The results of the literature study found several impacts of green building implementation on building users in Indonesia. The following is an analysis of the positive and negative impacts of applying green building concepts on the health and comfort of building occupants in Indonesia as shown in Table 2.

Table 2. Positive and negative impact of green building implementation on the health and wellbeing of building users in Indonesia

Research Result	Positive Impact	Negative Impact
Joyoboyo Terminal has successfully implemented several aspects of green architecture, especially in terms of natural ventilation and lighting through the use of openings and plants (Rachmalia et al., 2023)	1. Reduction of pollution due to the presence of plants. 2. Natural ventilation from the opening design. 3. Natural lighting from the sun on the opening design side.	1. Lack of air ventilation in some parts of the building because it only relies on the opening design, resulting in heat. 2. Lack of ventilation in the center of the building, requiring the use of central air conditioning. 3. Lack of natural lighting in the center of the building so it requires lights.
The design of Banyuwangi Airport's facade has shown that with careful planning and the right material selection, we can create a comfortable and energy-efficient building in a tropical climate (Rossa et al., 2023)	1. The use of low transmittance materials and facade elements in the form of louvers and terraces can reduce the heat temperature which provides thermal comfort. 2. Having large enough openings and minimal walls allows the wind to blow inside the building which also adds to thermal comfort.	
Intiland Tower Surabaya has successfully implemented the principles of sustainable architecture in a comprehensive manner. The implementation of various strategies, ranging from waste management, energy efficiency, material selection, to health and comfort aspects,	1. The number of terrace openings equipped with sun shading and windows provides comfort for users, especially during the day which becomes less hot with room humidity set at an average temperature of 25 degrees C. 2. The implementation of a no smoking area provides fresh air production in the building.	

Research Result	Positive Impact	Negative Impact
shows the building's commitment to environmental sustainability (Sutjipto et al., 2023)	3. The height of 12 floors and built not in the city center causes the building to be far from noise and on floors with low levels can be overcome by vegetation around the building.	
The green building concept applied to Banyuwangi International Airport has a marked impact on enhancing passenger comfort (Cahyaningrum and Yudianto, 2023)	1. Wide enough ventilation openings can provide natural ventilation.	1. The wide ventilation openings cause noise greater than that of an airplane during takeoff or landing. 2. The entry of wild animals such as birds, bats and other pests causes nuisance.
Jakarta International Stadium (JIS) has successfully implemented the green building concept significantly. This is evidenced by the acquisition of Greenship Platinum certification from the Green Building Council Indonesia (GBCI). This achievement places JIS as one of the leading green buildings in Indonesia and sets a good example for other development projects (Widyakusuma, 2023)	1. Small holes or perforations in the design of the JIS main building facilitate air circulation into the stadium building, allowing air to flow naturally so that air will enter to cool down, especially for the tribune area inside the stadium. 2. The use of EFTE membrane on the roof of JIS as an exterior panel allows JIS to receive sunlight even when the stadium roof is closed. 3. The installation of CO_2 (carbon dioxide) gas monitoring sensor is very useful to help detect the level of CO_2 gas air quality in a building.	
The design of the Bimoku Bus Terminal Building is a good example of how architecture can integrate local cultural values with sustainability principles. The application of the green architecture concept in this building not only provides environmental benefits, but also improves the quality of life of the community (Baidani and Dwi Wahyudi, 2021)	1. The high roof form provides natural ventilation due to the utilization of the tendency of the wind to blow from north to south. 2. The selection of glass material as a roof covering and using the concept of a skylight model provides the benefits of sunlight as a source of light during the day and moonlight or stars as a source of lighting at night inside the terminal building.	
Green building principles have become a cornerstone for architects and planners in creating sustainable structures, as they often prioritize careful design and construction. These efficient buildings can also help mitigate the effects of climate change on both the structure and its occupants (Sudarman et al., 2021)	1. In office buildings, the maximum building height of 5 floors maximizes the plants planted around the building to absorb UV rays which will maximize oxygen production in the building environment. 2. The layout and facade of the office building are designed in such a way as to reduce the impact of hot land.	

Research Result	Positive Impact	Negative Impact
	3. The use of green roofs in office buildings reduces the heat temperature in the building. 4. Natural ventilation allows air circulation into the office. 5. Installation of CO_2 level detectors and ventilation settings that ensure the need for fresh air provide comfort for campus building users.	
Al-Ahdhar Mosque design has successfully utilized the potential of natural lighting and ventilation to create a relatively comfortable environment. However, there are still some aspects that need to be improved to achieve optimal thermal comfort (Vidiyanti et al., 2020)	1. Fixed windows with large openings provide natural lighting from morning to noon in the building 2. Although the air temperature in the mosque is quite high, the air velocity in the mosque is quite high through openings placed in various directions, so the air condition in the Al Ahdhar mosque is not stuffy and is still considered cool by building users.	1. Fixed windows do not provide ventilation.
Building Q at Petra Christian University has successfully implemented green building features. The building's design and operations prioritize natural lighting and ventilation, resulting in energy efficiency and sustainability (Wijaya and Graciela, 2019)	1. Natural lighting from windows facing north and south to get sunlight. 2. Natural ventilation from the open space design and window openings.	
Grand City Surabaya has shown that green building concepts can be successfully applied to commercial buildings such as shopping centers. By combining innovative architectural design and appropriate technology, Grand City Surabaya has successfully created a healthier and more sustainable environment (Young and Kosasih, 2019)	1. The use of green walls on the walls of the outdoor area of the building helps reflect the sun's heat to provide cool air. 2. The use of green walls also helps reduce pollution from inside and outside the building. 3. The use of green walls at the entrance helps reduce vehicle noise outside the mall building. 4. The use of light shelf facades and skylights made of glass maximizes the entry of natural lighting.	
Trillium Residence and Office has successfully implemented the concept of environmentally friendly buildings through the selection of materials, lighting systems, and proper ventilation. The use of natural materials and passive systems has contributed to user comfort, energy efficiency, and environmental sustainability (Averina and Putri, 2019)	1. Smoking is not allowed in the Trillium Residence area because the building applies the concept of green building. 2. The use of natural building materials such as marble, stone and white ceramics that reflect light helps optimize natural lighting. 3. The utilization of large and many transparent glasses as openings and building walls maximizes natural lighting during the day.	1. The lobby area does have a large opening, but the opening is not the main source of air conditioning, so an artificial air conditioning system is used. 2. During the rainy season and cloudy weather, the building cannot utilize natural lighting.

Research Result	Positive Impact	Negative Impact
Green design for the Faculty of Medicine, Sebelas Maret university (UNS) Medical Education Building is the right step in realizing a sustainable and environmentally friendly building. By optimizing the use of natural resources, this design not only provides benefits for building users, but also contributes to environmental preservation (Budi et al., 2018)	1. Side entrance openings and the addition of green spaces facilitate better airflow, enhancing natural ventilation. 2. Green spaces in the center of the hall provide oxygen supply and create a cooler environment for building occupants.	
The University of Indonesia Library has successfully improved energy efficiency through solar energy utilization and passive building design, and the library's greywater treatment system contributes significantly to water conservation (Cahyani, 2018)	1. The use of solar energy is done through solar cells and roof skylights installed on the roof of the building provide natural lighting. 2. The University of Indonesia library applies good ventilation and wide openings so that air circulation is very good and natural ventilation in the building. 3. The library building is landscaped with 86% of its land area and is overgrown with various trees that are up to 30 years old providing pollutant reduction that makes the building feel beautiful.	
Suara Merdeka Tower has successfully implemented a number of green building principles quite well. Building users also play an active role in supporting energy saving efforts (Nabilla et al., 2018)	1. The type of glass on the building facade is a type of stopsol glass that provides visibility for the human eye (visibility), does not glare in reflecting light and the color of the glass is cool to the eye. 2. With an elongated plan form and linear pattern, and with many glass openings in each part of the office space, maximizing natural lighting into the room.	
Green School Bali is a model of sustainable education, incorporating green building practices into its design and curriculum. The school's focus on energy conservation and the use of bamboo materials reflects its commitment to environmental sustainability (Hapsari, 2018)	1. Good air quality as the building is in the forest away from city pollution. 2. The open design of the building and air conditioning using windmills through underground tunnels results in good air circulation and allows the building to stay cool on hot days. 3. To support teaching and learning activities carried out indoors, the roof of the classroom is equipped with skylights as a source of natural lightingg	

Previous research on green building implementation in Indonesia has shown various positive and negative impacts on the health and well-being of building users. The application of green architecture principles, such as natural ventilation, eco-friendly materials, and daylighting, has been shown to improve thermal comfort, reduce pollution, and support energy efficiency. For example, the Joyoboyo terminal and Banyuwangi Airport have successfully utilized ventilation and daylighting to improve comfort. However, challenges such as lack of ventilation in certain parts of the building and nuisance due to wild animal entry

at Banyuwangi Airport have also emerged. While green building provides significant benefits, some aspects still need to be refined to achieve optimal comfort and sustainability.Based on the studies presented, 40 positive and 8 negative impacts of implementing green building concepts on the health and comfort of building occupants have been identified. However, these impacts have not yet been systematically categorized. Systematic grouping is crucial as it enables the identification of specific areas—such as air quality, thermal comfort, lighting, and noise control—where green building concepts positively or negatively affect occupants. This categorization will not only facilitate a clearer understanding of how green building implementations influence different aspects of health and comfort but also help target improvements more effectively and address challenges. Moreover, it provides valuable insights for refining the design process and informs future research and policies aimed at maximizing the health and well-being benefits of green buildings. The following are the results of the analysis in the form of grouping the influence of the application of green building on the health and comfort of building users/occupants as can be seen in Table 3 and Table 4.

Table 3. Positive impacts of green building implementation for building occupants

References	Positive Impact				
	Air	**Natural Lighting**	**Natural Ventilation**	**Noise**	**Safety and Security**
(Rachmalia et al., 2023)	Point 1	Point 3	Point 2	-	-
(Rossa et al., 2023)	-	-	Point 1 and 2	-	-
(Sutjipto et al., 2023)	Point 2	-	Point 1	Point 3	-
(Cahyaningrum and Yudianto, 2023)	-	-	Point 1	-	-
(Widyakusuma, 2023)	Point 3	Point 2	Point 1	-	-
(Baidani and Dwi Wahyudi, 2021)	-	Point 2	Point 1	-	-
(Sudarman et al., 2021)	Point 1 and 5	-	Point 2, 3, and 4	-	-
(Vidiyanti et al., 2020)	-	Point 1	Point 2	-	-
(Wijaya and Graciela, 2019)	-	Point 1	Point 2	-	-
(Young and Kosasih, 2019)	Point 2	Point 4	Point 1	Point 3	-
(Averina and Putri, 2019)	Point 1	Point 1 and 2	-	-	-
(Budi et al., 2018)	Point 2	-	Point 1	-	-
(Cahyani, 2018)	Point 3	Point 1	Point 2	-	-
(Nabilla et al., 2018)	-	Point 2	-	Point 1	-
(Hapsari, 2018)	Point 1	Point 3	Point 2	-	-

Table 4. Negative impacts of green building implementation on building occupants

References	Negative Impact				
	Air	**Natural Lighting**	**Natural Ventilation**	**Noise**	**Safety and Security**
(Rachmalia et al., 2023)	-	Point 3	Point 1 and 2	-	-
(Rossa et al., 2023)	-	-	-	-	-
(Sutjipto et al., 2023)	-	-	-	-	-
(Cahyaningrum and Yudianto, 2023)	-	-	-	Point 1	Point 2
(Widyakusuma, 2023)	-	-	-	-	-
(Baidani and Dwi Wahyudi, 2021)	-	-	-	-	-

References	Negative Impact				
	Air	Natural Lighting	Natural Ventilation	Noise	Safety and Security
(Sudarman et al., 2021)	-	-	-	-	-
(Vidiyanti et al., 2020)	-	-	Point 1	-	-
(Wijaya and Graciela, 2019)	-	-	-	-	-
(Young and Kosasih, 2019)	-	-	-	-	-
(Averina and Putri, 2019)	-	Point 2	Point 1	-	-
(Budi et al., 2018)	-	-	-	-	-
(Cahyani, 2018)	-	-	-	-	-
(Nabilla et al., 2018)	-	-	-	-	-
(Hapsari, 2018)	-	-	-	-	-

The overall synthesis of Table 2 highlights that while green buildings generally offer significant environmental, energy, and health benefits, they also face operational challenges that must be addressed. Categorizing these impacts into areas like air quality, thermal comfort, lighting, and noise control can help architects and policymakers design more balanced and efficient green buildings. To enhance the positive impacts and mitigate the challenges, future green building projects in Indonesia should consider hybrid systems that combine natural and artificial elements, ensuring consistent comfort levels for occupants. For instance, integrating smart ventilation systems or using better noise insulation strategies could enhance occupant satisfaction without sacrificing the green building objectives. After conducting the analysis, we identified 40 positive impacts and 8 negative impacts of green building implementation on the health and comfort of building users/occupants, which can be categorized into two main groups:

3.1 Positive Impacts

A dominant positive theme in green building design is the integration of natural elements such as ventilation, lighting, and plant life, where buildings utilize terraces, open designs, and green roofs to enhance air circulation and thermal comfort, significantly reducing pollution and improving air quality. Additionally, the use of plants both inside and around buildings further supports air purification and thermal comfort, while energy efficiency is achieved by employing natural lighting and solar energy, minimizing dependence on artificial lighting and air conditioning and energy-efficient materials such as specially designed stop-sol glass to reduce the ingress of sunlight and heat into the space. Further amplifies energy savings, ultimately fostering sustainable building management; moreover, green buildings promote health benefits by improving indoor air quality, enforcing smoking restrictions, and implementing CO_2 monitoring systems, leading to healthier environments, where natural ventilation and air monitoring systems significantly improve occupant wellbeing. These influences are grouped into several aspects, namely:

3.1.1 Air Pollution Reduction

The use of plants and vegetation around buildings helps reduce air pollution and improve air quality, as reflected in studies showing that green spaces can provide sufficient oxygen supply and create a cool atmosphere in and around buildings (Rachmalia et al., 2023; Sudarman et al., 2021; Young and Kosasih, 2019; Budi et al., 2018). Buildings with green features and environmentally friendly materials provide better indoor environmental quality for occupants compared to conventional buildings, thereby reducing indoor pollution and improving occupants' health and productivity (Ghodrati et al., 2012).

3.1.2 Natural Lighting

Optimal opening design and the use of light-reflecting materials help maximize daylighting, which increases visual comfort for occupants and reduces energy requirements for artificial lighting.

Skylights and large openings allow sunlight to enter the space throughout the day, significantly improving the quality of daylighting within the building (Rachmalia et al., 2023; Baidani and Dwi Wahyudi, 2021; Cahyani, 2018; Averina and Putri, 2019). The more sustainable a building is, the less likely it is to have negative health impacts on building managers, occupants and the wider environment. The greener a building is in terms of materials and energy use patterns, the healthier it is (Ajayi et al., 2016).

3.1.3 Natural Ventilation

Good opening design and natural ventilation improve air circulation and help to keep the room temperature cool without the need for artificial air conditioning. Some buildings also utilize windmills and underground tunnels as part of the natural air conditioning system, which significantly improves thermal comfort (Rachmalia et al., 2023; Sutjipto et al., 2023; Cahyani, 2018; Hapsari, 2018). Previous studies have shown that the potential of natural ventilation is influenced by a combination of environmental factors, including climatic conditions, air exchange rate, and air quality, which impact the feasibility of natural ventilation (Xiong et al., 2024).

3.1.4 Minimized Sensory Disruptions

Designs that reduce noise from outside the building and the use of environmentally friendly materials help create a calm and comfortable environment for residents. In addition, the implementation of non-smoking areas and green environmental settings reduce pollutants and improve air quality inside buildings (Young and Kosasih, 2019; Hapsari, 2018; Sutjipto et al., 2023; Averina and Putri, 2019). Well-being is considered more comprehensive than comfort, which is often the focus of environmental designers. Comfort refers to a neutral and long-lasting state, but is essentially a relaxed or pleasant state. The experience of well-being in the workplace relies on multi-sensory experiences, both through the common five senses and additional sensory modalities such as thermoception and proprioception, provided by the building in which one works (Clements-Croome et al., 2019).

3.2 Negative Impacts

Despite the numerous advantages of green building designs, several challenges emerge, such as the reliance on natural ventilation and lighting, which may fail to provide adequate comfort in the building's center or during adverse weather conditions, leading to increased dependence on artificial air conditioning that can diminish the energy savings and environmental benefits intended by green design; additionally, while wide ventilation openings enhance airflow, they can also raise noise levels in areas near airports or busy roads and allow for the intrusion of wildlife, such as birds and pests, which can disrupt occupants. Although natural lighting is advantageous during the day, some buildings face challenges in maintaining adequate illumination during cloudy weather or at night, necessitating artificial lighting, highlighting the limitations of relying solely on natural sources without appropriate backup systems. These influences are grouped into several aspects, namely:

3.2.1 Inadequate Natural Lighting

Buildings that rely on natural lighting in only certain areas can result in insufficient lighting in other parts. This necessitates the use of artificial lighting to compensate for the lack of natural light, which can increase energy consumption and reduce visual comfort in poorly lit area (Rachmalia et al., 2023; Averina and Putri, 2019). This issue can be mitigated by orienting the building towards light sources and prevailing winds to balance the negative impacts on the building (Rattanongphisat and Rordprapat, 2014).

3.2.2 Insufficient Natural Ventilation

Uneven natural ventilation within a building can cause some areas, especially the interior, to become hot and require the use of artificial air conditioning. This can increase energy costs and reduce the energy efficiency that green building designs aim to achieve (Rachmalia et al., 2023; Vidiyanti et al.,

2020). The size and placement of windows significantly affect energy consumption, suggesting that careful consideration of window dimensions is crucial in building design (Kim et al., 2016). Additionally, surrounding environments, such as vegetation and plants, can enhance natural ventilation (Rattanongphisat and Rordprapat, 2014).

3.2.3 Noise Disruption

Wide ventilation openings can increase noise from outside, such as the sound of airplanes taking off or landing. This noise can disrupt the comfort and concentration of building occupants, thereby reducing their quality of life (Cahyaningrum and Yudianto, 2023). To address this issue, orienting ventilation openings away from noise sources, such as airports or busy roads, can help reduce noise intrusion (Xiong et al., 2024).

3.2.4 Safety and Security Issues

Wide openings in building design can also allow wildlife, such as birds or bats, to enter, which can disrupt activities inside and pose additional health risks. This indicates that green building designs should consider security and protection from external disturbances (Cahyaningrum and Yudianto, 2023). To address this issue, openings can be designed with easily closable features, such as windows or vents with covers, to prevent wildlife intrusion when not needed or when there is a risk (Chan et al., 2018).

4. Conclusions

Based on the literature review, it is evident that the implementation of green building practices in Indonesia has a profound impact on the health and well-being of building users. The findings reveal 40 positive and 8 negative impacts, which highlight the dual nature of these practices. The positive impacts include improved air quality due to pollution reduction, optimal natural lighting that enhances visual comfort, natural ventilation that boosts thermal comfort, and minimal sensory disruption, all of which contribute to better overall well-being. These benefits support the central objective of green buildings—to create healthier and more sustainable environments for occupants. However, several challenges remain, certain areas in buildings lack adequate natural lighting and ventilation, leading to reliance on artificial systems, which can undermine energy efficiency. Additionally, noise intrusion from external environments and wildlife intrusion poses potential risks to occupant comfort and safety. These limitations suggest that while the green building concept is promising, it requires refinements to achieve its full potential in promoting health and well-being. To improve the implementation of green buildings in Indonesia, future research should focus on addressing these operational challenges. This could include exploring hybrid systems that integrate natural and artificial elements to ensure consistent indoor comfort, as well as the development of innovative noise and wildlife control mechanisms.

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References

Ajayi, S.O., Oyedele, L.O., Jaiyeoba, B., Kadiri, K., David, S.A. 2016. Are sustainable buildings healthy? An investigation of lifecycle relationship between building sustainability and its environmental health impacts. World Journal of Science Technology Sustainable Development 13, 190–204.

Allen, J.G., MacNaughton, P., Laurent, J.G.C., Flanigan, S.S., Eitland, E.S., Spengler, J.D. 2015. Green buildings and health. Current Environmental Health Reports 2, 250–258.

Altan, H., Hajibandeh, M., Tabet Aoul, K.A., Deep, A. 2016. Passive design. Springer Tracts in Civil Engineering hlm. 209–236.

Ardyan, M., Hassan, S.M., Novianti, Y. 2023. Pengaruh konsep green building pada bangunan rumah

tinggal. Prosiding Seminar Nasional Teknik Sipil dan Arsitektur (Senastesia) hlm. 1–12.

Arifin, R., Ashandi;, Prayogi, L. 2019. Penerapan konsep arsitektur hijau pada pusat konservasi ekologi kawasan pesisir di Jakarta Utara. Jurnal Purwarupa 3, 207–212.

Averina, G., Putri, O.T. 2019. Analisis pemilihan material, pencahayaan, dan penghawaan pada apartemen Trillium Surabaya kajian terapan eko-interior. Seminar Nasional Infrastruktur Berkelanjutan Era Revolusi Industri 4.0 Teknik Sipil dan Perencanaan hlm. 11–18.

Bahaudin, A.Y., Elias, E.M., Saifudin, A.M. 2014. A comparison of the green building's criteria. E3S Web of Conferences 3, 1–10.

Baidani, N., Dwi Wahyudi, H. 2021. Sistem pencahayaan dan penghawaan pada desain gedung terminal bus Bimoku. Prosiding Seminar Nasional Aplikasi Sains & Teknologi (SNAST) hlm. F80–F85.

Budi, J.B.S., Fifthariski, K., Yuliani, S., Setyaningsih, W. 2018. Strategy of green design implementation for optimizing of the natural ventilation at high-rise building. Arsitektura 16, 155.

Cahyani, O.I. 2018. Penerapan konsep green architecture pada bangunan perpustakaan Universitas Indonesia. Jurnal Ilmiah Desain Konstruksi 17, 76–85.

Cahyaningrum, S.D., Yudianto, K. 2023. Pengaruh penerapan konsep green building terhadap kenyamanan pengguna jasa di terminal bandar udara internasional Banyuwangi. Jurnal Ilmiah dan Karya Mahasiswa 1, 112–120.

Chaerani, E.Y., Firmansyah, A. 2024. Kebijakan dan penerapan green building di Indonesia: Suatu tinjauan. Jurnalku 4, 68–78.

Chan, A.P.C., Darko, A., Olanipekun, A.O., Ameyaw, E.E. 2018. Critical barriers to green building technologies adoption in developing countries: The case of Ghana. Journal of Cleaner Production 172, 1067–1079.

Clements-Croome, D., Turner, B., Pallaris, K. 2019. Flourishing workplaces: A multisensory approach to design and POE. Intelligent Buildings International 11, 131–144.

Dejong, T. 2023. Conference proceedings versus journal papers - Chronica Horticulturae 63/2 (June 2023). Acta Horticulturae 63, 5–6.

Ghodrati, N., Samari, M., Mohd Shafiei, M.W. 2012. Green buildings impacts on occupants' health and productivity. Journal of Applied Sciences Research 8, 4235–4241.

Hapsari, O.E. 2018. Analisis penerapan green building pada bangunan pendidikan (Studi kasus : Green School Bali). Al-Ard Jurnal Teknik Lingkungan 3, 54–61.

Harzing, A.-W. 2011. The publish or perish book, 1st edition, Scientometrics. Tarma Software Research Pty Ltd, Melbourne.

Ijong, J.F. 2018. Konsep pengembangan bangunan hijau di kawasan tepian pesisir perkotaan Tahuna. Jurnal Fraktal 3, 61–68.

Kim, S., Zadeh, P.A., Staub-French, S., Froese, T., Cavka, B.T. 2016. Assessment of the impact of window size, position and orientation on building energy load using BIM. Procedia Engineering 145, 1424–1431.

MacNaughton, P., Satish, U., Laurent, J.G.C., Flanigan, S., Vallarino, J., Coull, B., Spengler, J.D., Allen, J.G. 2017. The impact of working in a green certified building on cognitive function and health. Building and Environment 114, 178–186.

Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A., Aromataris, E. 2018. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Medical Research Methodology 18, 1–7.

Nabilla, S.R., Sari, S.R., Murtini, T.W. 2018. Penerapan green building di perkantoran Menara Suara Merdeka, Semarang. Natural National Academy Journal Architecture 5, 124.

Newsham, G.R., Birt, B.J., Arsenault, C., Thompson, A.J.L., Veitch, J.A., Mancini, S., Galasiu, A.D., Gover, B.N., MacDonald, I.A., Burns, G.J. 2013. Do green buildings have better indoor environments? New evidence. Building Research and Information 41, 415–434.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L.,

Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D. 2021. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. British Medical Journal 372.

Prasetia, V., Rahayu, T.E.P.S., Tarigan, R.A.P. 2022. Green building assessment of Cilacap State Polytechnic: Building A. Jurnal Presipitasi Media Komunikasi dan Pengembangan Teknik Lingkungan 19, 290–302.

Rachmalia, I., Romadhoni, N., Tarra, B.M., Arfianti, A. 2023. Pengaruh bukaan terhadap penghawaan dan pencahayaan alami pada bangunan terminal Joyoboyo Surabaya. Seminar Nasional Arsitektur Pertahanan 2023 – UPN "Veteran" Jawa Timur hlm. 174–188.

Rattanongphisat, W., Rordprapat, W. 2014. Strategy for energy efficient buildings in tropical climate. Energy Procedia 52, 10–17.

Rossa, A., Alfian Firmansyah, M., Zuhri, S., Studi Arsitektur, P., Timur, J., Rungkut Madya, J. 2023. Pengaruh desain fasad bandara Banyuwangi terhadap kenyamanan termal 113–123.

Sahid, S., Sumiyati, Y., Purisari, R. 2021. Strengthening green building policies in Indonesia. IOP Conference Series: Earth and Environmental Science hlm. 1–7.

Sahid, Sumiyati, Y., Purisari, R. 2020. The constrains of green building implementation in Indonesia. Journal of Physics: Conference Series hlm. 1–11.

Sudarman, S., Syuaib, M., Nuryuningsih, N. 2021. Green building: Salah satu jawaban terhadap isu sustainability dalam dunia arsitektur. Teknosains Media Informasi Sains dan Teknologi 15, 329.

Sutjipto, P.B., Mauludy, Y.R. Al, Aulia, A.Z., Susanti, W.D. 2023. Penerapan konsep arsitektur berkelanjutan pada bangunan perkantoran Intiland Tower Surabaya. Seminar Nasional Arsitektur Pertahanan 2023 – UPN "Veteran" Jawa Timur hlm. 26–38.

Vidiyanti, C., Siswanto, R., Ramadhan, F. 2020. Pengaruh bukaan terhadap pencahayaan alami dan penghawaan alami pada masjid Al Ahdhar Bekasi. Jurnal Arsitektur Zo 3, 20–33.

Widyakusuma, A. 2023. Prinsip green building Jakarta International Stadium untuk arsitektur kota Jakarta yang berkelanjutan. Jurnal TRAVE XXVII 66–79.

Wijaya, F., Graciela, G. 2019. Sistem pencahayaan dan penghawaan hemat energi pada gedung Q Universitas Kristen Petra. Seminar Nasional Infrastruktur Berkelanjutan Era Revolusi Industri 4.0 hlm. 1–10.

Xiong, J., Li, B., Short, C.A., Kumar, P., Pain, C. 2024. Comprehensive evaluation of natural ventilation potential of buildings in urban areas under the influence of multiple environment-related factors. Journal of Building Engineering 89, 109218.

Yasinta, R.B., Pradana, M.A., Dahlia, D. 2024. Analyzing green building of appropriate site development requirements in high rise building. Jurnal Presipitasi Media Komunikasi dan Pengembangan Teknik Lingkungan 21, 132–143.

Young, S., Kosasih, A.P. 2019. Analisis sistem pencahayaan dan penerapan green wall pada mall Grand City Surabaya. Seminar Nasional Infrastruktur Berkelanjutan 2019 Era Revolusi Industri 4.0 137–144.

Zakiah, A. 2023. Green building implementation challenge for housing from developer perspective in Indonesia. Arsitektura 21, 39.

Zitars, J., Spadafore, B., Coulombe, S., Riemer, M., Dreyer, B.C., Whitney, S. 2021. Understanding the psycho-environmental potential functions of a green building to promote employee health, wellbeing and productivity: A theoretical perspective. Building and Environment 205, 108268.