Drivers for Implementing Green Building Concept to Vertical Housing Construction in Indonesia Based on Stakeholders' Perspective

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Abstract: The Indonesian government encourages vertical housing development to meet housing needs, especially in urban areas. It is a national programme that steadily increases in number and affects the environment. Hence, the development of sustainable principles needs to be carried out. However, implementing a green building concept to vertical housing construction in Indonesia is not mandatory, is relatively more expensive than conventional projects and can negatively affect the environment. Therefore, this research aimed to determine the drivers for implementing the green building concept in vertical housing in Indonesia. A mixed-method approach was selected. Based on literature studies, an open questionnaire was distributed to 76 respondents from the green community, including regulators (government), architects, engineers and academics. To analyse the data, content analysis, distribution analysis and analysis of variance (ANOVA) were used. The result showed that "Saving" (34.6%), "Generating a positive environmental impact" (26.9%), "Improving the quality of residents' lives" (19.2%), "Optimising building performance" (10%) and "Mitigating carbon emissions" (9.2%) were the drivers for implementing green building concept from the respondents. The details of this concept that needed to be implemented included site management, energy efficiency and conservation, wastewater management, waste management, water efficiency and conservation, material sources and cycles, continued green efforts, and indoor health and comfort. This research offers insight for policymakers and practitioners navigating sustainable development in vertical housing construction in Indonesia.

Keywords: Housing construction, Drivers, Green building, Indonesia, Vertical housing

INTRODUCTION

Over the period from 1990 to 2019, carbon dioxide emissions from buildings increased by 50%, leading to a 38% increase in global final energy consumption, whose 32% originated from the residential sector (IPCC [Intergovernmental Panel on Climate Change], 2022). In 2019, global greenhouse gas emissions from buildings accounted for 21% of the total global emissions. Within this figure, 57% were attributed to indirect emissions from power generation and heating, 24% were direct onsite emissions and 18% originated from the use of cement and steel.

In Indonesia, the industrial and construction sectors contribute to the largest share of final energy consumption, approximately 43.9%, followed by the household sector (31.2%), transportation (17.05%) and other consumers (7.6%) (BPS -

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Statistics Indonesia, 2021). Nonetheless, the housing demand in Indonesia still faces significant unmet needs, as indicated by the recorded backlog of housing units, which amounted to 7.6 million units in 2015. Over the subsequent four years, by 2019, the backlog was only reduced by 2.2 million units, highlighting a remaining shortage of 5.4 million housing units. The strategic plan of the Directorate of High-Rise Housing of the Ministry of Public Works and Public Housing for the period from 2020 to 2024 mentioned that one of the government's policies to address this housing backlog is the implementation of the *Program Sejuta Rumah* (A Million House Programme). *Program Sejuta Rumah* encompasses various types of housing, including apartment buildings (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2020).

Despite the government's initiatives to construct affordable housing, there is a notable lack of environmentally conscious practices in vertical housing development, resulting in high energy consumption. Therefore, there is a pressing need for present-day vertical housing development to prioritise the reduction of negative impacts and strive to generate positive effects on climate and the environment by implementing green building concepts. The World Green Building Council (WGBC) defines a green building as a structure that, in its design, construction and operation, diminishes or eliminates negative impacts and creates positive effects on both the climate and natural environment (WGBC, 2022).

The green building assessment systems were first introduced by the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom in 1990. The systems have been widely adopted in various countries such as Canada, Hong Kong and New Zealand (BRE Group, 2022; Haapio and Viitaniemi, 2008; Todd et al., 2001; Xiaoping, Huimin and Qiming, 2009). Meanwhile, Indonesia was pioneered by GREENSHIP, owned by the Green Building Council Indonesia (GBCI), in 2009, marking the initiation of green building assessment systems in the country (Larasati, 2018). In addition to GREENSHIP by GBCI, other assessment systems utilised in Indonesia include the Leadership in Energy and Environmental Design (LEED) from the United States (Haapio and Viitaniemi, 2008; USGBC [United States Green Building Council], 2022a; Xiaoping, Huimin and Qiming, 2009), which is also implemented in Canada, Spain, India, China and the Green Building owned by the Ministry of Public Works and Public Housing (Sujatmiko et al., 2020). The advancement of green building assessment systems in Indonesia has gained momentum following the issuance of Minister of Public Works and Public Housing Regulation Number 21 of 2021 concerning the Performance Assessment of Green Buildings (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2021a).

Zulkepli, Sipan and Jibril (2017) aimed at developing green building assessment criteria for green affordable housing in Malaysia using high-reliability criteria: energy efficiency, sustainable site and management, water efficiency, materials and resources, indoor air quality and innovation. Braulio-Gonzalo, Jorge-Ortiz and Bovea (2022) examined indicators from specialised green building assessment systems for residential buildings from eight applicable systems in various countries (BREEAM, LEED, CASBEE/Comprehensive Assessment System for Built Environment Efficiency, Green Star, Green Globes, DGNB/German Sustainable Building Council and VERDE). Aspects related to assessment indicators for residential buildings from the eight assessment systems consisted of comfort, energy, environmental awareness, materials, natural resources and climate change, waste and water. From the research findings, prevailing assessment systems focus on embedded

impact evaluation rather than designing a holistic approach across the building's life cycle. This is because most indicators are related to the product and construction stages (Braulio-Gonzalo, Jorge-Ortiz and Bovea, 2022). Several assessment systems, one of which is LEED, have also implemented the green building assessment system for residential properties, which divides its assessment into two categories for single-family and multifamily residences (USGBC, 2022b).

Certification of green building practices in Indonesia began with the certification of Bintan Lagoon Resort at the Silver level by GBCI in 2011 (GBCI, 2023). Over time, green building certifications (accredited by GBCI, LEED and Bangunan Gedung Hijau [BGH], Ministry of Public Works and Public Housing) have predominantly been awarded to office buildings. However, the government is actively constructing affordable apartment buildings to address housing shortages. Efforts in housing provision aim at accommodating sustainable development concepts, climate change mitigation and adaptation, as well as disaster risk reduction (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2021b). Nevertheless, several policies related to green buildings, such as Government Regulation Number 16 of 2021 and Ministry of Public Works and Housing Regulation Number 21 of 2021 on the performance assessment of green buildings, only recommend that vertical housing be assessed rather than mandated.

While significant efforts have been made to address housing shortages in Indonesia through the construction of vertical housing development, there remains a gap in the adoption of environmentally conscious practices within this development. Despite the government's initiatives to construct affordable housing, the implementation of green building concepts remains optional, leading to high energy consumption and environmental impact. This highlights a research gap in understanding the drivers for adopting green building concepts to vertical housing in Indonesia. Existing studies have explored various drivers for implementing green building, including economic, social and environmental factors, yet there is a need for further investigation, specifically focusing on the Indonesian context. Additionally, while certification systems and assessment methods for green buildings have been introduced in Indonesia, their effectiveness and impacts on vertical housing development remain underexplored. Therefore, this research aimed at addressing this gap by identifying the key drivers for implementing green building concepts to vertical housing in Indonesia, providing valuable insights for policymakers and practitioners to guide sustainable development efforts in the country.

LITERATURE REVIEW

The Construction of Vertical Housing

As urbanisation in developing countries is still increasing, especially in Africa and Asia, it can lead to negative consequences, such as uncontrolled urban growth, low-density urban development, high dependence on private cars, housing shortages, construction of informal settlements, social and territorial isolation of the population, poverty, crime and other social ills. There are some principles to solve those problems, one of which is high-density urban development that includes active vertical development. Another principle is mixed-uses among residential, commercial and production functions, as well as personal services and recreational areas (Generalova et al., 2016).

Many cities in developed and developing countries are embracing vertical buildings and their technologies. Some even tried to make them functionally sustainable for the environment and prepare for vertical sustainable housing construction through a public-private partnership approach in public housing delivery (Afolabi, Akinbo and Akinola, 2019).

In line with the research by Afolabi, Akinbo and Akinola (2019), Yusuf and Elghonaimoy (2020) discussed the aspects that need to be considered in terms of the quality of sustainable vertical housing projects, such as environmental conditions, including noise, thermal and heat factors, humidity and condensation, natural lighting and ventilation and green roof. Economic considerations include modern technology for providing services for each unit in electricity, water supplies, sewage disposal and solid waste management. The last aspect is social consideration, which includes housing design and the relation among vertical cities' components, construction systems, privacy and density, aspects of designs and building materials (Yusuf and Elghonaimoy, 2020).

The Roles of Stakeholders in Green Building Implementation

When considering the pivotal role of stakeholders, it is essential to understand how governmental policies and incentives shape the landscape of green building initiatives. According to Li et al. (2022), prior research primarily focused on key stakeholders such as clients, contractors, buyers, government and designers, reflecting their significant influence on successfully implementing green building projects. Despite facility managers being recognised as crucial participants in green buildings, they have received limited attention in research, indicating that green buildings are still in the early stages of development. As scholars have primarily aimed at promoting green building adoption and improving its delivery process, the focus should shift towards ensuring environmental performance during the operational stage as green buildings enter a rapid development phase. Additionally, there is a growing need to engage secondary stakeholders, including suppliers, green consultants, assessors and demolition companies, who play a vital role in providing essential information on green products and mitigating potential risks associated with green strategies (Huo and Yu, 2017; Zuo and Zhao, 2014).

Government subsidies significantly incentivise green building, promoting green building development (Feng et al., 2021). However, the effectiveness of the distribution of the subsidies, particularly those directed at homebuyers, warrants closer examination. Also, providing subsidies to homebuyers might not yet play a positive role in selecting green buildings because buyers are passive regarding green buildings. Therefore, the government needs to implement measures to stimulate demand for green buildings among buyers. For example, the construction process cannot be separated from government supervision, suggesting imposing punishments on construction units for non-compliance with green standards and the government's own losses and supervision costs when supervision is not strict.

The role of stakeholders, particularly the government, holds significant influence in developing green building initiatives. Insufficient government incentives rank highest among the identified challenges. The increased upfront costs represent a major obstacle for all stakeholders involved. Therefore, government incentives emerge as a crucial element for advancing green building initiatives (Chan, Qian and Lam, 2009; Deng et al., 2018; Windapo, 2014). At the same time, Chan et al. (2018) noted that government-related barriers hinder the adoption

of green buildings in developing countries. They emphasised the importance of strengthening green building policies and regulations, with input from various stakeholders such as academics, associations, building owners, contractors and practitioners. Moving beyond the realm of incentives, it is crucial to assess broader challenges faced by stakeholders in green building implementation, particularly emphasising the role of governmental policies and regulations.

In addition, cooperative endeavours between governmental bodies and market influences are vital for fostering the green construction sector's sustainable advancement (Qiao, Dong and Ju, 2022). This includes the need to gain a more profound comprehension of the interconnections between governmental regulations and market fluctuations. Several useful managerial insights and suggestions could be derived from the proposed synergistic development framework and experimental results to help generalise the results obtained. They are related to government policy formulation and real business operations and have the potential to help the green building industry move forward. Therefore, the government and the market should work together to promote the high-quality and rapid development of the green building market. Firstly, the government should pay more attention to the importance of technological innovation in the development of the green building market, encourage the application of emerging technologies such as 5G and artificial intelligence in engineering construction and promote the integration of green construction and new technologies. Secondly, it needs to introduce public-private-partnership to green construction, mobilise more social capital to join the green building market and accelerate the development of the green financial system. Finally, the construction industry should enter the carbon emission trading system as soon as possible to achieve carbon neutrality and carbon peak (Qiao, Dong and Ju, 2022).

Moreover, empirical studies have shed light on the readiness factors of stakeholders in the housing industry, providing valuable insights into the practical considerations influencing the adoption of green building practices. For example, Gomez and Yung (2018) studied the readiness factors of the housing industry's key stakeholders to implement green buildings. The result showed the relative importance of the design teams' competencies and commitment to designing green building projects and the factors affecting developers' decision to procure green buildings. Berawi et al. (2019) offered a nuanced perspective on the awareness and motivations of stakeholders in embracing green building concepts, highlighting the pivotal role of governmental initiatives in driving widespread adoption in Indonesia. They also explored the awareness of stakeholders in Indonesia regarding green building implementation, particularly on environmental concerns. Their research highlighted energy efficiency and water conservation as primary motivations for building owners to embrace the green building concept. According to their findings, there is a consensus that the government should be more proactive in accelerating nationwide green building adoption.

RESEARCH METHODOLOGY

Mixed methods can be defined by some elements, like collecting qualitative (open-ended) and quantitative (close-ended) data in response to research questions or hypotheses, including the analysis of both forms of data. The procedures for both qualitative and quantitative data collection and analysis needed to be conducted

rigorously (Creswell, 2014). Accordingly, a mixed-method approach was employed in the current study to achieve the research objectives. The current study combined qualitative approaches, namely literature studies and open-ended questionnaires, with a quantitative approach for data analysis.

The literature study was the first step of this research. It sought to discover how other studies find the drivers for implementing green building concepts. Then, the questionnaire (Step 2) involved the researcher's deliberate selection of individuals to facilitate a comprehensive understanding (Creswell, 2018). Data collection was carried out through an online questionnaire featuring open-ended questions. The study's three steps are shown in Figure 1.

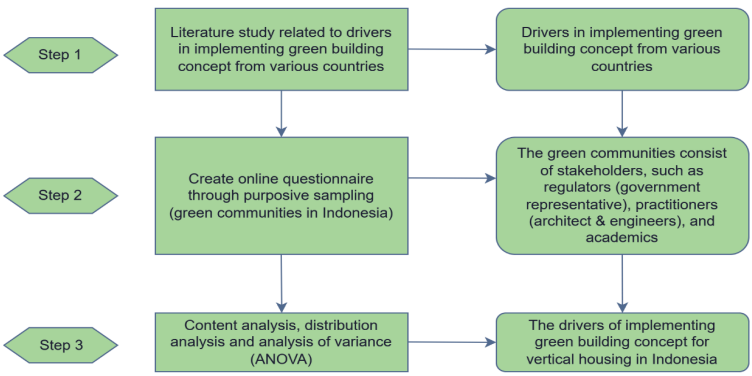

Figure 1. Research design

This research used purposive sampling to collect the data in qualitative research. This means that individuals and sites were selected for research because they could purposefully inform an understanding of the research problem and central phenomenon in the study (Creswell, 2007).

The questionnaire was distributed among various green communities in Indonesia, comprising stakeholders such as regulators (government representatives), practitioners (architects and engineers) and academics who are interested in developing green buildings in Indonesia to get various perspectives with the same basic knowledge about green buildings. The participants had experienced the phenomenon being studied (Creswell, 2007). The survey was administered from the end of August to the middle of September 2022 through some group messaging applications. Table 1 displays the questions of the study questionnaire.

The questionnaire was divided into two distinct sections. The first section gathered general information about the respondents, encompassing their educational background, education level and work experience. The subsequent section inquired about the drivers for integrating the green building concept into vertical housing, encompassing the necessity and rationale. Notably, the questions in the second and third sections were open-ended to allow respondents to provide detailed explanations in paragraph form.

Meanwhile, content analysis was employed in Step 3 for data analysis. The analysis identified drivers based on the responses to open-ended questions from the questionnaire. Their responses were grouped into segments, sub-categories

and main categories based on existing keywords. After identifying the main categories, a distribution analysis was conducted to examine how each driver was distributed. The next stage involved analysis of variance (ANOVA), a statistical procedure for partitioning the variability of measurements into systematic and random components (Judd, McClelland and Ryan, 2017).

Table 1. The questions of the questionnaire for construction stakeholders

	Structure of Questions on the Questionnaire (Open Question)
1	Stakeholders' educational background/expertise area and level.
2	Stakeholders' working experiences.
3	Stakeholders' opinions regarding the importance of vertical housings in implementing green building concept.
4	Stakeholders' opinions regarding the necessity of implementing green building concept to vertical housing.
5	The possibility of implementing green building concept to vertical housing.

ANALYSIS AND DISCUSSION

The first stage of the research was a literature study to summarise the top drivers for implementing green building in several research categorised based on the drivers' level of category by Darko, Zhang and Chan, (2017): external and internal drivers. The former can be defined as drivers mainly set by external parties, such as the government, United Nations (UN), European Union (EU), trade unions and clients/ customers, to companies or organisations of green building. In other words, the external driver refers to events that occur outside the company that develops green buildings. Meanwhile, the latter has four categories. First, corporate-level drivers enhance business in terms of sustainability. Then, project-level drivers mention things that are related to the quality, cost and time of the project. Next, property-level drivers include increased property value, high rental income and reduced risks. The last was individual-level drivers, such as human motivation, understanding, or behaviour (Darko, Zhang and Chan, 2017). Table 2 summarises the top drivers for implementing green building in several studies.

The open questionnaire was distributed in the second stage of this research. A total of 76 respondents attempted the questionnaire. Most respondents, 51 individuals (66.23%), had an architectural educational background, nine individuals (each 11.69%) had mechanical/electrical/plumbing (MEP) and civil/ structural backgrounds and the last eight (10.39%) had educational backgrounds other than those mentioned, consisting of landscape architecture, physics engineering, international relations and environmental engineering backgrounds. Regarding the level of education, 51 respondents were postgraduates, while the remaining 25 individuals graduated from the undergraduate level. Based on the duration of work experience, 33 respondents worked between 11 and 20 years of their work experience, 31 respondents had less than 10 years of working experience and 13 respondents had more than 21 years of working experience. Table 3 summarises the profile of respondents from the questionnaire.

Table 2. Literature study-based drivers for implementing green building concept

Drivers for Implementing Green Building Concept	Sources	Drivers Category				
		External	Project Level	Corporate Level	Property Level	Individual Level
Government regulation	Zhang, Wu and Liu (2018); Sharma (2018); Darko, Zhang and Chan (2017); Assylbekov et al. (2021); Ahn et al. (2013); Arif et al. (2009); Andelin et al. (2015)	√				
Energy efficiency	Durdyev et al. (2018); Zhang, Wu and Liu (2018); Darko, Zhang and Chan (2017); Assylbekov et al. (2021); Ahn et al. (2013); Arif et al. (2009); Andelin et al. (2015)				√	
Increased sales of rental levels	Mao and Yang (2011); Zhang, Wu and Liu (2018); Kim et al. (2020); Darko, Zhang and Chan (2017); Ahn et al. (2013); Andelin et al. (2015)			√		
Financial incentives	Mao and Yang (2011); Zhang, Wu and Liu (2018); Darko, Zhang and Chan (2017); Ahn et al. (2013); Arif et al. (2009)			√		
Improved quality of life of occupants	Darko, Zhang and Chan (2017); Assylbekov et al. (2021); Ahn et al. (2013); Arif et al. (2009); Andelin et al. (2015)			√		
Reduced lifecycle cost	Ahn et al. (2013); Arif et al. (2009); Andelin et al. (2015)				√	
Water efficiency	Durdyev et al. (2018); Darko et al. (2017); Assylbekov et al. (2021)				√	

Table 3. Respondent profiles

Variable	Category Areas of Expertise	Number	%
Educational background	Architecture	51	66.23
	MEP	9	11.69
	Civil/Structure	9	11.69
	Others	8	10.39
Educational level	Undergraduate	25	32.47
	Postgraduate	51	66.23
Work experience	Less than 10 years	31	40.26
	11 years to 20 years	33	42.86
	More than 21 years	13	16.88

Drivers or motivation is the strategy for accelerating the shift from conventional to environmentally friendly buildings (Feige, Wallbaum and Krank, 2011). According to Cole (2011), maintaining consistent engagement in green building techniques among various building stakeholders, including project owners, developers and constructors, demands motivation. Most respondents mentioned that the drivers for implementing the green building concept to vertical housing were related to its benefits, such as saving energy consumption, water consumption, operational costs and resource utilisation. Additionally, this implementation also affected the environment, including regulating green open spaces, managing waste effectively, creating balance, maintaining urban ecological systems, creating a healthy environment and reducing environmental temperatures. The third most common driver was improving residents' quality of life. Respondents believed that implementing the green building concept to vertical housing could improve the health and comfort of residents. Furthermore, reducing carbon emissions, which are closely related to greenhouse gases, was the fourth most common motivation mentioned by respondents. This was followed by the improvement of building performance, where there was an evident enhancement in the quality and functionality of the building itself, as well as the introduction of green building implementation, which is closely related to raising awareness about green building and assisting communities in creating green communities. Table 4 shows the main categories and sub-categories of drivers for implementing green building based on the questionnaire.

Table 4. Main categories and sub-categories for drivers for implementing green building concept to vertical housing in Indonesia

Main Categories for Drivers	Sub-Categories for Drivers
Saving	1. Reducing energy consumption
	2. Reducing water consumption
	3. Reducing operational cost
	4. Reducing the use of resources

(*Continued on next page*)

Table 4. *Continued*

Main Categories for Drivers	Sub-Categories for Drivers
Enhancing resident's quality of life	1. Improving health
	2. Improving comfort
Mitigating carbon emissions	Reducing greenhouse gases
Generating a positive environmental impact	1. Better waste management
	2. Better green open space management
	3. Creating positive impacts
Optimising building performance	1. Improving building function
	2. High complexity

Based on the distribution analysis (as shown in Figure 2), "Saving" was the most frequently mentioned driver by respondents (45 times), followed by "Generating a positive environmental impact" with 35 mentions, "Enhancing residents' quality of life" ranked third with 25 mentions and "Optimising building performance" and "Mitigating carbon emissions" with 13 and 12 mentions, respectively. Research conducted by Windapo (2014), Darko, Zhang and Chan (2017) and Bassas, Patterson and Jones (2021) also discovered that "Saving" is the driver most frequently mentioned by respondents indicating it as the most influential for implementing green building to vertical housing. This is also in line with the results of literature studies (e.g., Durdyev et al., 2018; Zhang, Wu and Liu, 2018; Darko, Zhang and Chan 2017; Assylbekov et al., 2021; Ahn et al., 2013; Arif et al., 2009; Andelin et al., 2015), which show the existence of "Saving" components, such as energy efficiency, water efficiency and reduced life cycle costs.

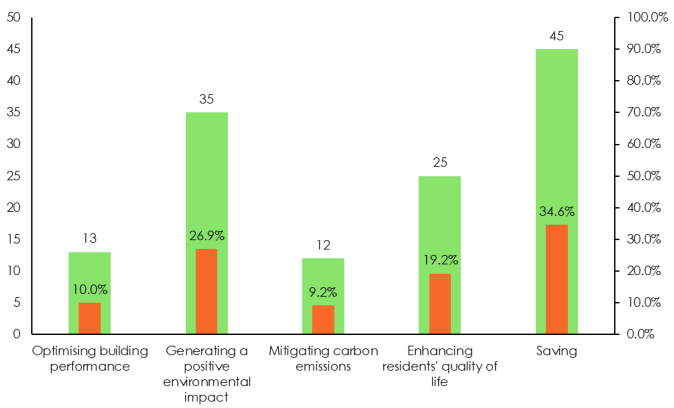

Figure 2. Distribution analysis results of drivers in implementing green building concept to vertical housing

Furthermore, the second largest driver was "Generating a positive environmental impact". This driver was not mentioned in prior literature studies. From several literature, the positive impact of implementing green building has usually been reduced to more specific concepts, such as saving energy, water, costs and resources. Additionally, respondents in this research answered that "Mitigating carbon emissions" also positively influenced the environment. This could be the implementation of green building is expected to have a positive effect and reduce negative environmental impacts (WGBC, 2016). Regarding "Enhancing residents' quality of life", respondents understood that implementing the green building concept to vertical housing would improve residents' health and comfort. "Optimising building performance" and "Mitigating carbon emissions" had a distribution that was not much different, with the distribution being the lowest compared to other drivers.

The drivers for implementing the green building concept are divided into internal and external motivations. The former is when specific psychological demands related to values, norms, beliefs, or societal concerns are met by completing green building projects (Olanipekun et al., 2017). In this research, "Saving" and "Enhancing residents' quality of life" was labelled as internal motivation. Meanwhile, the latter included "Generating a positive environmental impact", "Optimising building performance" and "Mitigating carbon emissions".

Figure 3 shows a Venn diagram of the intersection between the resume drivers for implementing green building concept to vertical housing from the literature study and respondents' answers.

A one-way ANOVA tests the statistical significance of the difference of means among three or more groups on one continuous variable (Vogt, 2005). In this research, ANOVA was used to determine the distribution of differences in drivers and green building concepts based on respondents' answers. From the analysis, there were significant differences between the drivers mentioned by respondents, with a significant value of < 0.0001 (as shown in Figure 4 and Table 5). The middle line in Figure 4 shows the median value of the questionnaire data. There were two data each above and below the line, while the other data was in the middle of the line. The data above the line referred to "Saving" and "Generating a positive environmental impact", but the former was higher than the latter. This indicated that most respondents chose those drivers. Meanwhile, the data below the line were "Mitigating carbon emissions" and "Optimising building performance", but the former was slightly lower than the latter. This indicated that fewer respondents chose the drivers. Furthermore, "Enhancing residents' quality of life" was on the median data line. This indicated that, on average, respondents chose this driver when implementing the green building concept to vertical housing. The variety of respondents' answers regarding drivers for implementing green building concepts to vertical housing indicated that even though they had similar knowledge about green building, the exposure to green building concepts or projects deepened their knowledge influencing how they responded to the open-ended questionnaire in this research.

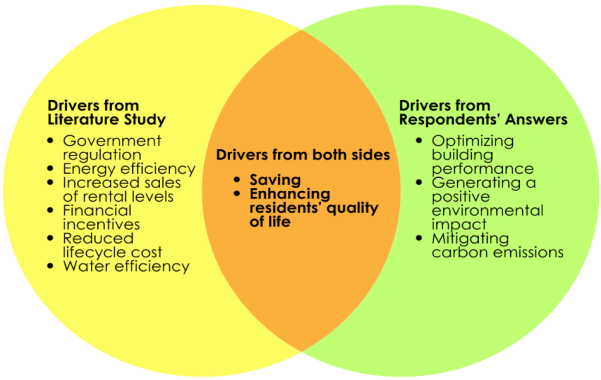

Figure 3. Drivers in implementing green building concepts from the literature study and respondents' answers

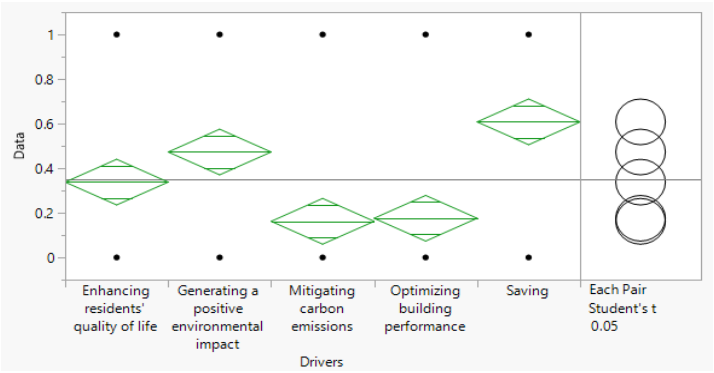

Figure 4. Drivers in implementing green building concepts

Table 5. Distribution of differences in drivers and green building concepts

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Drivers	4	10.918919	2.72973	13.5733	< 0.0001*
Error	365	73.405405	0.20111		
Corrected total	369	84.324324			

Note: * refers to the significant value.

Regarding the follow-up questions to respondents who stated that the green building concept needed to be applied to vertical housing, the respondents mentioned the concept that could be implemented. Their answers were categorised based on a combination of green building assessment criteria applied in Indonesia by the Ministry of Public Works and Public Housing and Green Building Council Indonesia (GBCI) (as shown in Table 6).

Figure 5 illustrates the distribution of green building concepts based on the questionnaire. "Energy efficiency and conservation" were the concepts most frequently mentioned by respondents (24.9%). The priorities highlighted by the respondents aligned well with the key drivers emphasised in the literature, particularly emphasising the importance of energy saving within the broader context of energy efficiency. Several studies, including by Lam, Yang and Liu (2006), Lin and Qin (2019) and Williams and Bourland (2010), underscore the significance of "Energy efficiency and conservation" in the implementation of green building practices. Specific aspects of energy efficiency include ventilation systems, lighting solutions, utilisation of renewable energy sources and efficient air conditioning systems as stated in Table 6. Additionally, "Site management" emerged as the second most frequently mentioned concept among respondents (17.8%). This finding corresponds with the assessment criteria outlined by the Ministry of Public Works and Public Housing and GBCI, where site management ranked the third highest-scoring criterion. Respondents elaborated that site management involved considerations such as optimising building orientation, designing effective building envelopes and providing private green open spaces.

Table 6. Green building assessment criteria used

Green Building Assessment Criteria			
Ministry for Public Works and Public Housing	**Point**	**GBCI**	**Point**
Site management	38	Appropriate site development	17
Energy efficiency	46	Energy efficiency and conservation	31
Water efficiency	22	Water conservation	21
Indoor air quality	19	Material resources and cycle	14
Sustainable material	21	Indoor health and comfort	10
Waste management	7	Building environment management	12
Wastewater management	12		
Total point	165	Total point	105

The third highest percentage was "Water management" as a green building concept that needed to be implemented in flats (12.4%). Furthermore, "Material sources and cycles", encompassing sub-categories such as local material, sustainable material and prefabricated material, became the fourth most frequently mentioned concept by respondents (11.6%). This was followed by "Water efficiency and conservation" and "Continued green efforts" with 11.1%, respectively. The green building concept with the second lowest percentage was "Wastewater management" and "Indoor health and comfort", with 7.6% and 3.6%, respectively. Table 7 shows the categories and sub-categories of green building concepts that could be applied to vertical housing.

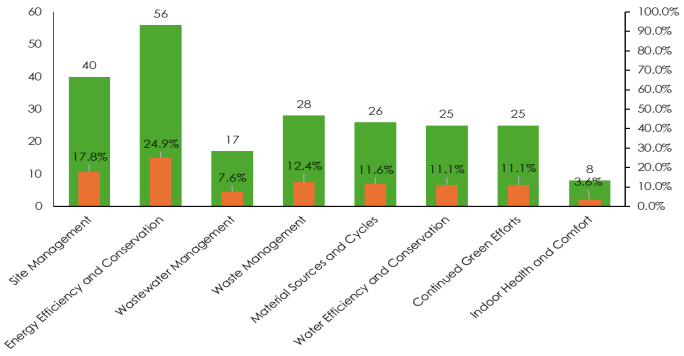

Figure 5. Distribution of implementing green building concept to vertical housing

Table 7. Main categories of green building concepts to vertical housing

Main Categories for Green Building Concepts	**Sub-Categories**
Site management	Building orientation
	Building envelope
	Private green open space
Energy efficiency and conservation	Ventilation system
	Lighting system
	Using renewable energy source
	Air conditioning system
Wastewater management	Wastewater management
Waste management	Waste management
Material sources and cycles	Local material
	Sustainable material
	Prefabrication material
Water efficiency and conservation	Water conservation
Continued green efforts	Enhanced performance
Indoor health and comfort	Indoor comfort

The results of the ANOVA analysis on the green building concept applicable to vertical housing demonstrate a significant distribution of data for each concept (as shown in Table 8), with a significance value of < 0.0001. Based on Figure 6, there were only two data above and four data below the median data line, while the remaining three data touched the line. "Energy efficiency and conservation", along with "Site management", exceeded the median data line. This indicated that most respondents considered these concepts highly implementable. Meanwhile, "Waste management" and "Wastewater management" were slightly below the

median line. This indicated a general consensus among respondents that these concepts were feasible for implementation. In contrast, "Building environmental management" and "Indoor health and comfort" were notably below the median data line, suggesting insufficient attention from respondents regarding the potential implementation of these concepts. Besides that, "Continued green efforts", "Material sources and cycles" and "Water efficiency and conservation" aligned with the median data line, suggesting moderate consideration among respondents for these concepts.

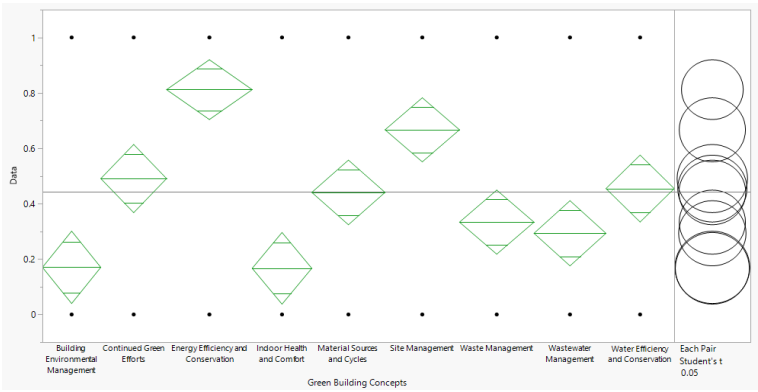

Figure 6. Green building concepts to be implemented

Table 8. Distribution of differences in green building concepts

Source	Degrees of Freedom	Sum of Squares	Mean Square	*F* Ratio	Probability > F
Green building concepts	8	21.69061	2.71133	13.0398	< 0.0001*
Error	500	103.96362	0.20793		
Corrected total	508	125.65422			

Note: * refers to the significant value.

CONCLUSIONS

The findings of the current study underline the drivers for implementing green building concepts in vertical housing and the importance of implementing environmentally friendly building concepts in vertical housing development, especially in the context of housing challenges and environmental problems in Indonesia. "Saving", "Generating a positive environmental impact", "Enhancing residents' quality of life", "Optimising building performance" and "Mitigating carbon emissions" were the drivers stated by the respondents in implementing green building concepts to vertical housing in Indonesia, with "Saving" and "Generating a positive environmental impact" being the major drivers.

The analysis of this study revealed significant gaps in respondent's perceptions of various green building concepts, emphasising the importance of supporting energy efficiency and conservation alongside site management for the green building concepts. These concepts were considered highly implementable and aligned with global trends and literature emphasising the important role of energy-saving measures in green building initiatives. Moreover, the study highlighted moderate consideration for continued green efforts, material sources and cycles and water efficiency and conservation, indicating a broader interest in sustainable practices among respondents. However, there are still significant gaps in prioritising wastewater management, as well as building environmental management and indoor health and comfort, indicating that these areas require more attention and awareness.

The research underlines the urgent need for vertical housing development to integrate green building concepts to reduce environmental impacts and improve overall sustainability. By highlighting key drivers and prioritising the green building concept that needs to be implemented, this study provides valuable insight for policymakers, developers and practitioners seeking to advance sustainable housing practices in Indonesia's vertical housing sector.

Future research should focus on analysing the regulation in vertical housing, exploring the affordability through the cost-benefit of vertical housing with green building concepts and developing model regulations for stakeholder collaboration to encourage widespread adoption of green building in vertical housing developments in Indonesia.

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REFERENCES

Afolabi, A., Akinbo, F. and Akinola, A. (2019). Vertical architecture construction: Prospects and barriers in solving Lagos' housing deficit. *Journal of Physics: Conference Series*, 1378(4): 1–6. https://doi.org/10.1088/1742-6596/1378/4/042032

Ahn, Y.H., Pearce, A.R., Wang, Y. and Wang, G. (2013). Drivers and barriers of sustainable design and construction: The perception of green building experience. *International Journal of Sustainable Building Technology and Urban Development*. https://doi.org/10.1080/2093761X.2012.759887

Andelin, M., Sarasoja, A.-L., Ventovuori, T. and Junnila, S. (2015). Breaking the circle of blame for sustainable buildings: Evidence from Nordic countries. *Journal of Corporate Real Estate*, 17: 26–45. https://doi.org/10.1108/JCRE-05-2014-0013

Arif, M., Egbu, C., Haleem, A., Ebohon, J. and Khalfan, M.M. (2009). Green construction in India: Gaining a deeper understanding. *Journal of Architectural Engineering*, 15: 10–13. https://doi.org/10.1061/(ASCE)1076-0431(2009)15:1(10)

Assylbekov, D., Nadeem, A., Hossain, M.A., Akhanova, G. and Khalfan, M. (2021). Factors influencing green building development in Kazakhstan. *Buildings*, 11(12): 634. https://doi.org/10.3390/buildings11120634

Bassas, E.C., Patterson, J. and Jones, P. (2020). A review of the evolution of green residential architecture. *Renewable and Sustainable Energy Reviews*, 125: 109796.

Berawi, M.A., Miraj, P., Windrayani, R., Rohim, A., Berawi, B. and Berawi, M.A. (2019). Stakeholders' perspectives on green building rating: A case study in Indonesia. *Heliyon*, 5(3): e01328. https://doi.org/10.1016/j.heliyon.2019

BPS - Statistics Indonesia (2021). *Energy Balances of Indonesia 2016–2020*. Jakarta: BPS - Statistics Indonesia.

Braulio-Gonzalo, M., Jorge-Ortiz, A. and Bovea, M.D. (2022). How are indicators in Green Building Rating Systems addressing sustainability dimensions and life cycle frameworks in residential buildings? *Environmental Impact Assessment Review*, 95: 106793. https://doi.org/10.1016/j.eiar.2022.106793

BRE Group (2022). BREEAM. Available at: https://bregroup.com/products/breeam [Accessed on 10 November 2022].

Chan, A.P.C., Darko, A., Olanipekun, A.O. and 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. https://doi.org/10.1016/j.jclepro.2017.10.235

Chan, E.H.W., Qian, Q.K. and Lam, P.T.I. (2009). The market for green building in developed Asian cities: The perspectives of building designers. *Energy Policy*, 37: 3061–3070. https://doi.org/10.1016/j.enpol.2009.03.057

Cole, R.J. (2011). Motivating stakeholders to deliver environmental change. *Building Research and Information*, 39(5): 431–435. https://doi.org/10.1080/09613218.2011.599057

Creswell, J.W. (2018). *Educational Research Planning, Conducting and Evaluating Quantitative and Qualitative Research*. 6th Ed. London: Pearson.

———. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*. Los Angeles: SAGE Publications, Inc.

———. (2007). *Qualitative Inquiry and Research Design: Choosing among Five Approaches*. 2nd Ed. Los Angeles: SAGE Publications, Inc.

Darko, A., Zhang, C. and Chan, P.C. (2017). Drivers for green building: A review of empirical studies. *Habitat International*, 60: 34–49. https://doi.org/10.1016/j.habitatint.2016.12.007

Deng, W., Yang, T., Tang, L. and Tang, Y.T. (2018). Barriers and policy recommendations for developing green buildings from local government perspective: A case study of Ningbo, China. *Intelligent Buildings International*, 10: 61–77. https://doi.org/10.1080/17508975.2016.1248342

Durdyev, S., Zavadskas, E.K., Thurnell, D., Banaitis, A. and Ihtiyar, A. (2018). Sustainable construction industry in Cambodia: Awareness, drivers and barriers. *Sustainability,* 10(2): 392. https://doi.org/10.3390/su10020392

Feige, A., Wallbaum, H. and Krank, S. (2011). Harnessing stakeholder motivation: Towards a Swiss sustainable building sector. *Building Research and Information*, 39: 504–517. https://doi.org/10.1080/09613218.2011.589788

Feng, L., Yang, S., Zhou, Y. and Shuai, L. (2021). Exploring the effects of the spatial arrangement and leaf area density of trees on building wall temperature. *Building and Environment*, 205: 108295. https://doi.org/10.1016/j.buildenv.2021.108295

GBCI (Green Building Council Indonesia) (2023). Certified building in Indonesia. Available at: https://gbcindonesia.org/certbuilding [Accessed on 15 January 2024].

Generalova, E., Generalov, V., Potienko, N. and Generalova, E.M. (2016). Affordable Housing under Shaping Dense Vertical Urbanism. *CTBUH 2016*. Shenzhen, Guangzhou, Hong Kong, 650–659.

Gomez, C.P. and Yung, G.T.T. (2018). Housing industry readiness factors and indicators to implement green building development. *International Journal of Sustainable Construction Engineering and Technology,* 9: 44–57. https://doi.org/10.30880/ijscet.2018.09.01.004

Haapio, A. and Viitaniemi, P. (2008). A critical review of building environmental assessment tools. *Environmental Impact Assessment Review*, 28: 469–482. https://doi.org/10.1016/j.eiar.2008.01.002

Huo, X. and Yu, A.T.W. (2017). Analytical review of green building development studies. *Journal of Green Building*, 12: 130–148. https://doi.org/10.3992/1943-4618.12.2.130

IPCC (Intergovernmental Panel on Climate Change) (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge, UK/New York: Cambridge University Press. https://doi.org/10.1017/9781009325844

Judd, C.M., McClelland, G.H. and Ryan, C.S. (2017). *Data Analysis*. 3rd Ed. New York: Routledge.

Kementerian Pekerjaan Umum dan Perumahan Rakyat (2021a). Peraturan menteri PUPR no. 21 tahun 2021. Available at: https://jdih.pu.go.id/detail-dokumen/2881/1#div_cari_detail [Accessed on 15 January 2024].

——— (2021b). *Laporan Kinerja Direktorat Jenderal Perumahan Tahun 2021*. Jakarta: Kementerian Pekerjaan Umum dan Perumahan Rakyat.

——— (2020). *Rencana Strategis Direktorat Rumah Susun Tahun 2020–2024*. Jakarta: Kementerian Pekerjaan Umum dan Perumahan Rakyat.

Kim, K. H., Jeon, S.-S., Irakoze, A. and Son, K. (2020). A study of the green building benefits in apartment buildings according to real estate prices: Case of non-capital areas in South Korea. *Sustainability*, 12(6): 2206. https://doi.org/10.3390/su12062206

Lam, J.C., Yang, L. and Liu, J. (2006). Development of passive design zones in China using bioclimatic approach. *Energy Conversation Management*, 47: 746–762. https://doi.org/10.1016/j.enconman.2005.05.025

Larasati, D. (2018). *Buku Ajar Arsitektur Hijau*. Bandung, Indonesia: ITB Press.

Li, Y., Li, M., Sang, P., Chen, P.-H. and Li, C. (2022). Stakeholder studies of green buildings: A literature review. *Journal of Building Engineering*, 54: 104667. https://doi.org/10.1016/j.jobe.2022.104667

Lin, P. and Qin, H. (2019). Energy Efficient Design Strategies for Affordable Housing. In A. Olanrewaju, Z. Shari and Z. Gou (eds.), *Greening Affordable Housing: An Interactive Approach*. Florida: CRC Press Taylor & Francis Group, 167–189.

Mao, Y.H. and Yang, G.H. (2011). Sustainable development drivers for green buildings: Incremental costs-benefits analysis of green buildings. *Advanced Materials Research*, 374–377: 76–81. https://doi.org/10.4028/www.scientific.net/amr.374-377.76

Olanipekun, A.O., Xia, B., Hon, C. and Hu, Y. (2017). Project owners' motivation for delivering green building projects. *Journal of Construction Engineering and Management*, 143(9): 04017068. https://doi.org/10.1061/(asce)co.1943-7862.0001363

Qiao, W., Dong, P. and Ju, Y. (2022). Synergistic development of green building market under government guidance: A case study of Tianjin, China. *Journal of Cleaner Production*, 340: 130540. https://doi.org/10.1016/j.jclepro.2022.130540

Sharma, M. (2018). Development of a "Green Building Sustainability Model" for green buildings in India. *Journal of Cleaner Production*, 190: 538–551. https://doi.org/10.1016/j.jclepro.2018.04.154

Sujatmiko, W., Yusniewati, Suhedi, F., Kusumawati, F., Rahmawati, Y. and Gumilar, R.P. (2020). *Sistem Rating Bangunan Gedung Hijau*. 2nd Ed. Bandung, Indonesia: Kementerian Pekerjaan Umum dan Perumahan Rakyat.

Todd, J.A., Crawley, D., Geissler, S. and Lindsey, G. (2001). Comparative assessment of environmental performance tools and the role of the Green Building Challenge. *Building Research and Information* 29: 324–335. https://doi.org/10.1080/09613210110064268

USGBC (United States Green Building Council) (2022a). LEED rating system. Available at: https://www.usgbc.org/leed [Accessed on 10 November 2022].

———. (2022b). LEED v4.1. Available at: https://www.usgbc.org/leed/rating-systems/residential [Accessed on 10 November 2022].

Vogt, P. (2005). *Dictionary of Statistics and Methodology: A Nontechnical Guide for the Social Sciences*. 3rd Ed. Los Angeles: SAGE Publications.

WGBC (World Green Building Council) (2022). What is a green building? Available at: https://www.worldgbc.org/what-green-building [Accessed on 19 October 2022].

———. (2016). About green building: World green building council 2016–2022. Available at: https://www.worldgbc.org/what-green-building [Accessed on 19 October 2022].

Williams, S. and Bourland, D. (2010). Green affordable housing: Enterprise's green communities initiative. In G. Kats (ed.), *Greening Our Built World: Costs, Benefits and Strategies*. Washington DC: Island Press, 40–45.

Windapo, A. (2014). Examination of green building drivers in the South African construction industry: Economics versus ecology. *Sustainability*, 6: 6088–6106. https://doi.org/10.3390/su6096088

Xiaoping, M., Huimin, L. and Qiming, L. (2009). A comparison study of mainstream sustainable/green building rating tools in the world. In *2009 International Conference on Management and Service Science*. Piscataway, NJ: Institute of Electrical and Electronic Engineers, Inc. (IEEE). https://doi.org/10.1109/icmss.2009.5303546

Yusuf, M.B. and Elghonaimoy, I.H. (2020). Housing dilemma and vertical dimensions. *Civil Engineering and Architecture*, 8: 1107–1118. https://doi.org/10.13189/cea.2020.080537

Zhang, L., Wu, J. and Liu, H. (2018). Policies to enhance the drivers of green housing development in China. *Energy Policy*, 121: 225–235. https://doi.org/10.1016/J.ENPOL.2018.06.029

Zulkepli, M., Sipan, I. and Jibril, J.D. (2017). An exploratory factor analysis and reliability analysis for green affordable housing criteria instrument. *International Journal of Real Estate Studies*, 11: 9–21.

Zuo, J. and Zhao, Z.Y. (2014). Green building research-current status and future agenda: A review. *Renewable and Sustainable Energy Reviews*, 30: 271–281. https://doi.org/10.1016/j.rser.2013.10.021