Jurnal Arsitektur Zonasi

Journal homepage:
https://ejournal.upi.edu/index.php/jaz

Architectural Innovations in the Development of Sustainable Villas for Tourism in Lembang

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ABSTRACT

Lembang, as one of the leading tourist destinations in Indonesia, holds great potential for the development of environmentally friendly and sustainable rental villas. This study aims to analyze effective regional planning strategies for the development of rental villas with a focus on sustainability. The method used is mixed methods, combining a survey of 311 tourists who stayed in rental villas and in-depth interviews with local stakeholders, including villa owners, tourism managers, and local communities. The survey results show that 80% of tourists prefer environmentally friendly accommodations, with 65% supporting the use of renewable energy, 70% favoring efficient waste management, and 75% preferring environmentally friendly building materials. The interviews revealed that 70% of stakeholders believe that good planning can enhance the tourist experience and minimize negative impacts on the local community. The novelty of this research lies in the integrative approach that combines regional planning, environmentally friendly technology, and local community involvement in every stage of rental villa development. This research contributes to the development of sustainability-based regional planning theories and offers practical recommendations for local government policies to support sustainable tourism. These findings are expected to provide insights into the development of environmentally friendly rental villas in Lembang.

ARTICLE INFO

Article History:
Submitted/Received 18 Mar 2025
First Revised 14 April 2025
Accepted 24 May 2025
First Available online 30 May 2025
Publication Date 02 Jun 2025

Keyword:
Rental villas,
sustainability,
tourism,
environmentally friendly technology,
community involvement

1. INTRODUCTION

Lembang District, located in West Bandung Regency, is one of Indonesia's premier tourist destinations, known for its captivating natural charm. The beauty of Lembang's landscape, surrounded by mountains, tea plantations, and cool air, has made it a popular destination for both domestic and international tourists. With more than 49 tourist attractions, Lembang continues to grow as a tourism area with great potential, especially in the eco-friendly and sustainable accommodation sector. However, this rapid development does not come without environmental challenges, one of which is the threat of forest fires. As explained by Abrham et al. (2025), forest fires have significant ecological, economic, and social impacts. Forest fires destroy vast areas of natural vegetation, leading to biodiversity loss and long-term damage to ecosystems. The increasing frequency of forest fires—largely driven by climate change—is also emphasized by Abrham et al. (2025), who noted that in recent decades, fires have become more frequent and more destructive, particularly due to changing climate conditions. Therefore, effective fire management strategies are crucial to protect this tourist area. As suggested by Abrham et al. (2025), effective fire management and prevention strategies—including public awareness, sustainable tourism practices, and international cooperation—are essential to reduce the adverse impacts of forest fires.

In addition, the management of natural resources such as water is also a vital aspect to consider in tourism area planning. Restrepo Marín et al. (2024) stated that the hydrosocial cycle is a socio-natural process through which water and society continuously shape each other over time and space, highlighting the importance of integrating natural resource management with communities in regional development. In this context, community involvement in regional planning and management is essential. As described by Restrepo Marín et al. (2024) in their participatory methodology, the "Transformative Actions La Honda" methodology was applied to diagnose the hydrosocial cycle in the area, involving both community members and the academic sector to create nature-based solutions. In terms of architectural design, an approach that integrates natural beauty with modern and traditional architectural concepts can enhance the visitor experience in Lembang. As explained by Zhang & Baek (2025), the architectural promenade concept developed by Le Corbusier is also a significant design concept in the contemporary works of Wang Shu, illustrating how architectural design can blend seamlessly with natural landscapes. In his design philosophy, Wang Shu takes a poetic approach to exploring and living among mountains and waters, unfolding like a continuous scroll (Zhang & Baek, 2025). This approach can be adapted to create rental villas that are not only eco-friendly but also in harmony with the surrounding environment, offering a deeper experience for tourists. With the rising demand for renewable energy, the development of rental villas in Lembang should take into account energy-efficient and environmentally friendly consumption. Hsueh et al. (2021) emphasized that the use of renewable energy is a major concern in sustainable development, underscoring the importance of applying eco-friendly technologies in the tourism sector. Therefore, efficient and sustainable energy management will be a key element in the development of rental villas that support sustainable tourism in Lembang.

The importance of effective architectural planning is crucial in the development of tourism areas such as Lembang. Accommodations that align with local character—such as rental villas that integrate natural and cultural elements—can enhance the tourist experience while preserving ecosystem sustainability. Environmentally sensitive architecture not only supports aesthetics but also plays a vital role in the conservation of nature and local culture. As noted by Rato-Martín et al. (2020), urban planning that evolves with attention to local resources and regional needs can lead to harmonious transformation, as seen in Peñafiel, which

DOI: http://doi.org/10.17509/jaz.v8i2.81556
p- ISSN 2621-1610 e- ISSN 2620-9934

developed an urbanization model based on local resources and regional services. This demonstrates that integrating architectural planning with the area's natural and cultural potential can foster sustainable development aligned with local characteristics. Moreover, geographic factors also play a significant role in determining the success of architectural planning. Rato-Martín et al. (2020) explain that geographic elements—such as strategic positions that facilitate communication and human settlement—have a major influence on a region's early development. Therefore, when planning the development of rental villas in Lembang, it is important to consider the region's geography, which is surrounded by mountains and tea plantations, to ensure that development does not harm the local natural ecosystem. However, poorly planned tourism development can negatively impact the environment, as seen in the Traslasierra Valley, where uncontrolled urbanization has led to the loss of natural ecosystems. Cavallero et al. (2024) reported that more than 80% of new buildings in that region were constructed near forest areas, resulting in damage to natural habitats. Therefore, sustainability-based architectural planning is essential to avoid similar impacts in Lembang, emphasizing the importance of proper zoning and environmentally friendly design.

A major challenge in developing rental villas in Lembang is balancing economic growth with environmental preservation. The increasing number of tourists and demand for sustainable accommodation could place significant pressure on the local ecosystem if not properly managed. As highlighted by Cavallero et al. (2024), "The rise in construction in areas categorized as high conservation value under Forest Law indicates a failure in the implementation and enforcement of land use regulations." This illustrates how improper land management can threaten protected areas. Factors such as inadequate land use regulations, tourism promotion policies, and urban-to-rural migration also contribute to urban expansion, further exacerbating environmental pressure (Cavallero et al., 2024). Climate change is another factor that influences tourist decisions, where "tourism is highly dependent on climate and natural resources. For instance, 'warmer' climates are generally more attractive for recreation and leisure" (Gössling & Hall, 2006). This suggests that environmental factors affected by climate change must be taken into account in the development of sustainable tourism accommodations in Lembang. Additionally, uncertainty in tourist flow prediction models should also be considered, as "tourism is highly vulnerable to low-probability events, including terrorism, war, epidemics, and natural disasters" (Gössling & Hall, 2006). Therefore, it is important to design rental villas with consideration for potential disruptions that could impact the tourism sector. Integrating mitigation strategies through eco-friendly and sustainable architectural design is essential to addressing these challenges.

Eco-friendly and sustainable architecture can enhance the tourism appeal of a region. In Lembang, the design of rental villas that integrate local elements—such as natural building materials, open designs that maximize natural views, and renewable energy systems—can create a more authentic and engaging tourist experience. As Abrantes (2024) stated, "*The landscape is not just a space viewed and drawn from the outside; it is a taskscape, shaped by the practices and movements of its inhabitants, interwoven with time and history.*" This illustrates that architecture integrated with the natural landscape not only creates visually beautiful spaces but also connects visitors with the historical and cultural values of the area. Sustainability in the architectural design of rental villas in Lembang must encompass various aspects, from the selection of environmentally friendly building materials to the implementation of technologies for energy efficiency and waste management. Innovative technologies such as 3D concrete printing (3DCP) offer numerous benefits, including design freedom, formwork-free construction, lower construction costs, and reduced material waste (Alhaidary, 2024). However, the implementation of 3DCP still faces challenges, particularly

DOI: http://doi.org/10.17509/jaz.v8i2.81556
p- ISSN 2621-1610 e- ISSN 2620-9934

related to high technology and material costs and the lack of standardized practices (Alhaidary, 2024).

Designs that take into account the natural and cultural context will strengthen the identity of the area and create a more immersive experience for visitors. As explained by Pilgreen et al. (2025), *"Miscalibration of objective and subjective knowledge undermines the decision to engage in climate action during future travel by reducing climate-related attitudes,"* highlighting the importance of sustainability awareness in tourist decision-making. Sustainability also includes social aspects, involving the local community in the development and management of the villas. Through community participation, not only can economic well-being be improved, but deeper connections can also be fostered between tourists and the surrounding environment. As emphasized in Pilgreen et al. (2025), *"Attitudes were positively linked to past actions and future intentions for climate-friendly travel planning."* Actively involving local communities in the development process will create a more authentic experience and raise awareness about the importance of environmental preservation.

This study offers a novel approach to the development of sustainable rental villa architecture in Lembang by prioritizing innovative design that combines environmental sensitivity with respect for local culture. The main novelty of this research lies in the integration of sustainable architecture with spatial planning that involves the active participation of local communities at every stage of development. In contrast to previous studies that have primarily focused on technical or economic aspects, this research emphasizes the importance of collaboration among stakeholders—including the community—in the design and management of rental villas. This approach aims to create a development model for rental villas that is not only environmentally friendly but also supports local economic empowerment, preserves cultural authenticity, and enhances the quality of the tourist experience. Therefore, the outcomes of this research are expected to provide a more holistic and sustainable solution, creating synergy between tourism infrastructure development and the social and ecological sustainability of Lembang.

2. RESEARCH METHOD

This study employs a mixed methods approach, combining both quantitative and qualitative techniques to understand and analyze effective regional planning strategies for the development of rental villas in Lembang. This approach is chosen to provide a more comprehensive and holistic understanding of the phenomenon being studied. The research is carried out through several stages, involving appropriate techniques for data collection and analysis. In the quantitative data collection, a survey will be conducted by distributing questionnaires to 311 tourists who stay in rental villas in Lembang. The survey aims to gather data on tourist preferences regarding the types of accommodation, desired facilities, and their expectations of the lodging experience. The figure of 311 respondents is based on the representative sample theory, which suggests that a sample size greater than 300 provides sufficiently valid and representative data in social research (Cohen, 1988). In this case, 311 respondents were selected as they represent the relevant tourist population.

DOI: http://doi.org/10.17509/jaz.v8i2.81556
p- ISSN 2621-1610 e- ISSN 2620-9934

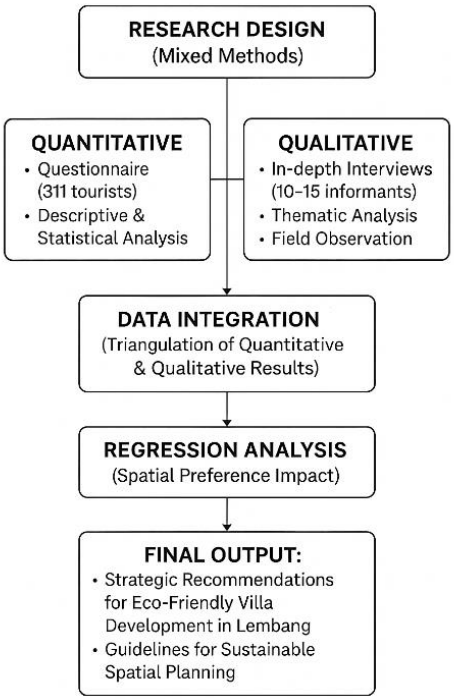

Figure 1. Graphic Stages of Research Methods
(Source: Author's Concept, 2025)

For qualitative data collection, in-depth interviews will be conducted with rental villa owners, local tourism managers, and community members to gain deeper insights into the challenges and opportunities in rental villa development. Field observations will also be carried out to examine actual conditions at development sites, including existing infrastructure, accessibility, and interactions between visitors and local residents. The sampling criteria will include a minimum target of 311 tourists, as well as 10 to 15 key informants selected using purposive sampling, a method that targets individuals with in-depth knowledge of the research subject (Bernard, 2006).

$$n = \frac{z^2 \,.\, p \,.(1-p)}{e^2}$$

Using 311 respondents from a population of 1,834,256 people in West Bandung Regency, the sample size remains valid and representative, even though it is slightly smaller than the ideal sample size of 384 respondents. With this sample size, the margin of error and confidence level are still within acceptable limits, although there is a slight reduction in statistical accuracy and power compared to a larger sample. Therefore, 311 respondents still provide a reliable representation of the population, with minimal risk of estimation error. The quantitative data obtained from the survey will be analyzed using descriptive and statistical methods to identify relationships between variables such as villa facilities, pricing, and location. Meanwhile, the qualitative data from interviews will be analyzed using thematic analysis to gain in-depth insights into informants' perceptions and experiences regarding rental villa development. This approach refers to the regional economic planning theory (Meyer, 2017) and sustainable tourism in spatial planning (Weaver, 2006) to integrate social, economic, and environmental factors in tourism area development. The findings from both quantitative and qualitative analyses will be combined to formulate more holistic and targeted recommendations for the development of rental villas in Lembang. Regression analysis will be applied to measure the influence of specific factors on tourist preferences, referring to spatial analysis theory in planning (Anselin, 2005). Through this approach, the

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p- ISSN 2621-1610 e- ISSN 2620-9934

research is expected to produce applicable and valid recommendations for the development of environmentally friendly and sustainable rental villas.

3. RESULTS AND DISCUSSION

3.1 Preferences for Environmentally Friendly Accommodation

Based on a survey conducted with 311 tourists staying in rental villas in Lembang, it was found that 80% preferred environmentally friendly accommodations that are integrated with nature. Additionally, the majority of respondents showed a strong preference for the use of renewable energy, with 65% stating the importance of renewable energy usage in rental villas. Efficient waste management was also highly valued, with 70% supporting eco-friendly waste management systems. Furthermore, 75% of respondents favored villas constructed with environmentally friendly building materials, indicating a high level of awareness regarding sustainability in accommodation choices. These findings align with global trends in the construction industry, which increasingly prioritize sustainability and efficiency. For example, in a case study of a twin villa project utilizing Building Information Modeling (BIM) and Value Engineering (VE), the integration of both technologies resulted in a 42% reduction in flooring material costs, a 30% reduction in door material costs, and total project cost savings of 35% (Gouda Mohamed et al., 2024). This demonstrates that advanced technologies like BIM and VE not only contribute to architectural design but also help reduce development costs and enhance efficiency—ultimately supporting more environmentally friendly construction.

Moreover, in the context of sustainability, reducing water consumption is another critical aspect of sustainable building design. Research indicates that embodied water in building materials, both initial and recurring, can account for up to 70% of total water consumption throughout a building's lifecycle (Rauf et al., 2024). Structural elements, primarily composed of concrete and steel, are responsible for approximately 40% of the accumulated water consumption in a building. Therefore, efficient and optimized design—such as reducing concrete slab thickness without compromising performance—can significantly lower the embodied water in construction materials and promote broader water-saving efforts (Rauf et al., 2024).

Table 1: Tourist Preferences Regarding Sustainability Aspects in Rental Villas in Lembang

Sustainability Aspect	Percentage of Respondents (%)
Use of Renewable Energy	65%
Efficient Waste Management	70%
Use of Environmentally Friendly Building Materials	75%
Nature-Integrated Accommodation	80%

(Source: Research Document)

This data clearly shows that tourists are increasingly aware of the importance of sustainability in tourism, particularly when it comes to the accommodations they choose. It highlights that the development of rental villas in Lembang should consider sustainability factors that can enhance their appeal to environmentally conscious travelers.

3.2 Local Community Involvement in the Management of Rental Villas

Interviews with 10 to 15 key informants, including villa owners, tourism managers, and local community members, showed that 70% of them believe that good planning in the development of rental villas can enhance tourists' experiences and minimize negative impacts on the local community. Active involvement of the local community, both in the planning and management of villas, has been proven to provide significant benefits in improving their economic welfare as well as creating authentic experiences for tourists. This indicates that close collaboration between developers, local governments, and the local community is

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p- ISSN 2621-1610 e- ISSN 2620-9934

essential to create sustainable and mutually beneficial tourism development. Local community involvement can also be seen in the importance of understanding and integrating cultural and historical contexts into architectural design. In this regard, rental villa architecture in Lembang can take inspiration from various architectural forms with historical value, such as the hexagonal shape, which is rarely used in late antique architecture but can still be found throughout the Roman Empire, including Roman villas, baths, funerary buildings, and early Christian baptisteries (Dobosi, 2024). The use of this unique architectural form, which often had different functions despite similar designs, can serve as an important symbol in rental villa design that reflects the diversity of local culture (Dobosi, 2024).

Furthermore, sites like Stabiae, considered a uniquely significant archaeological site, demonstrate how architectural influence can create a close relationship between buildings and their natural surroundings. The Stabiae site, offering panoramic sea and mountain views directly from its villas, provides deep insight into how ancient architecture interacted with its natural environment (Howe & Gardelli, 2015). This concept can be adapted for rental villa designs in Lembang, functioning not only as spaces that provide comfort for visitors but also integrate natural elements to create a deeper experience. The use of technology in design and construction can also enhance the efficiency of rental villa management. The integration of Building Information Modeling (BIM) with Value Engineering (VE) can significantly improve project efficiency, quality, and cost-effectiveness, allowing real-time adjustments and dynamic cost modeling (Gouda Mohamed et al., 2024). This shows that combining technology with sustainable construction practices can help reduce costs and increase sustainability in rental villa development. With active involvement of the local community, the utilization of architectural designs relevant to local culture and history, and the application of modern technology in project management, the development of rental villas in Lembang can create sustainable and beneficial solutions for all parties involved.

3.3 Environmental Management as a Tourism Attraction Factor

Good environmental management, which integrates natural elements and local culture into the architectural design of rental villas, has proven to be an important factor in increasing the attractiveness of tourist areas. Environmentally sensitive architecture not only supports aesthetics but also plays a role in preserving nature and local culture. This is important for enriching the tourist experience and attracting more visitors who care about sustainability. For example, the impact of tourism on indigenous territories can affect native communities, as found in research on city creation in the Mapuce region of Argentina. The study identified that tourism activities relevant both nationally and internationally can cause territorial conflicts with indigenous communities (Rodríguez et al., 2022). These conflicts have increased, especially in areas such as Villa Pehuenia-Moquehue and Villa La Angostura, where tourism development has exacerbated issues of deterritorialization of indigenous communities and their land rights (Rodríguez et al., 2022).

This highlights the importance of environmental management involving local communities to create shared awareness in maintaining a balance between tourism development and the preservation of culture and indigenous rights. For example, the design of Muraka, an underwater hotel in the Maldives, is intended to provide an experience of living in a foreign environment while building new relationships with marine life. This concept emphasizes the importance of human presence in harmony with the surrounding nature (Vannini & Vannini, 2024). With this approach, rental villa designs can offer a deeper and more sustainable experience for tourists. The biophilic design concept is also highly relevant in increasing tourist satisfaction, especially in creating a connection between humans and nature. Research shows that biophilic features, which integrate natural elements into

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p- ISSN 2621-1610 e- ISSN 2620-9934

buildings, can enhance visitor satisfaction despite challenges related to certain features in high-rise building designs (Shakhshir & Sheta, 2024). This biophilic design, also applied in the context of Dubai, is increasingly important in creating tourism experiences that harmoniously connect human elements with nature. Thus, good environmental management through architectural design focused on natural elements and sustainability will create stronger and more authentic tourist attractions for visitors, while maintaining the balance of ecosystems and local culture.

3.4 Zoning for Land Use Management

Proper zoning in tourism area development is very important for managing land use efficiently. By designating specific zones for rental villas, it is expected to maintain a balance between economic development and environmental preservation. Well-planned zoning also allows managers to reduce pressure on local ecosystems and minimize the negative impacts of rapid urbanization. For example, in a study conducted in Malaysia, the LSTM prediction model proved accurate in forecasting tourism demand, showing that spatial and temporal data analysis can help plan tourism zones more efficiently (Tsamienah et al., 2025). The use of this technology can optimize space allocation for various types of tourism facilities, including rental villas, by taking into account fluctuations in demand.

The implementation of well-planned zoning also supports more efficient use of space, as seen in a study on land use in the village of Bongkasa Pertiwi. There, most land use is directed towards tourism facilities, including tourist attractions, homestays, hotels, and villas (Anggawirya et al., 2022). With clear zoning, these facilities can be well integrated into the tourism area without disrupting the sustainability of the local ecosystem. Additionally, factors such as physiography, economic policies, as well as existing regulations and policies play important roles in determining appropriate land use (Anggawirya et al., 2022). The role of infrastructure is also crucial in supporting sustainable tourism development. Good infrastructure development, such as improving roads in tourism areas, will support visitor mobility and encourage better access to rental villa areas as well as other tourist destinations (Anggawirya et al., 2022). With careful zoning planning, pressure on ecosystems can be minimized, and tourism development can proceed sustainably with less environmental impact.

3.5 The Impact of Urbanization on Ecosystems

Urbanization in tourist areas often leads to the loss of natural ecosystems. For example, in the Traslasierra Valley, around 80% of new buildings constructed threaten natural habitats and cause damage to existing ecosystems. Increased urbanization pressure, driven by economic growth and demand for tourism facilities, can result in significant environmental degradation. Therefore, sustainability-based area management is essential to mitigate the negative impacts of uncontrolled urbanization. This becomes increasingly relevant considering that the growing tourism demand predictions require a more careful approach to managing ecosystems and land use (Tsamienah et al., 2025). Rapid urbanization, driven by uncontrolled development policies, often contributes to inefficient land use changes. For example, physiographic factors, economic policies, and existing regulations can influence how space is used in tourism areas, including land use for facilities such as rental villas and other tourist attractions (Anggawirya et al., 2022). Therefore, proper spatial planning and well-planned zoning policies are crucial to ensure that tourism development does not threaten environmental sustainability in the region.

Additionally, infrastructure supporting sustainable tourism plays an important role in reducing the impact of urbanization. Improvements in infrastructure quality, such as highways and public transportation facilities, not only enhance accessibility but can also

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p- ISSN 2621-1610 e- ISSN 2620-9934

reduce negative impacts on local ecosystems, allowing communities and visitors to enjoy natural beauty without damaging the environment (Hof & Blázquez-Salom, 2013). Community involvement in spatial planning and management is also important to ensure sustainability and avoid excessive pressure on local ecosystems.

3.6 The Role of Technology in Supporting Sustainability

Environmentally friendly technologies, such as renewable energy and efficient waste management systems, need to be integrated into the design of rental villas in Lembang. These technologies will not only improve the operational efficiency of the villas but also support long-term sustainability in the tourism sector, which is a key pillar in managing tourist areas With increasing awareness of sustainability, technologies that help reduce carbon footprints and utilize renewable energy, such as solar panels or wind turbines, become important in developing eco-friendly rental villas. Additionally, efficient waste management through technologies like water recycling or the use of environmentally friendly materials will also reduce negative impacts on local ecosystems. Good collaboration between local governments, villa managers, and the local community is essential in creating sustainable rental villa development. This cooperation ensures that the development of rental villas in Lembang not only provides economic benefits but also preserves the natural and cultural assets that are the main attractions of the area. Local governments can play a role in providing regulations that encourage sustainable development, while villa managers can implement environmentally friendly and sustainable technologies. The local community also has an important role in preserving local culture and the environment, as well as ensuring that tourism development provides direct economic benefits to them. As seen in the urbanization study in Peñafiel, changes in the area are strongly influenced by geographic factors and industrial developments that utilize local resources (Rato-Martín et al., 2020). Similarly, in the Lembang area, a regional planning approach that combines environmentally friendly technology with local community participation can result in more balanced and sustainable development. Furthermore, the impact of urbanization occurring in tourist areas, such as in the Traslasierra Valley—which causes the loss of natural ecosystems and the destruction of protected areas—highlights the importance of sustainability-based area management (Cavallero et al., 2024). Effective management must consider environmental, social, and economic aspects in regional development planning.

4. CONCLUSION

Activity support has a significant influence on the utilization of Sudirman Park as a public open space. Such activity support affects visitors' choices of activities, which in turn enliven the park's condition. The activity support currently available in Sudirman Park is still not optimal in supporting community activities within it. The most dominant activity support is street vendors (PKL), which sidelines and diminishes the activities that primarily benefit the park as a public open space. Therefore, optimization of other activity supports in the park is needed through various efforts that consider responsive, democratic, and meaningful aspects by paying attention to the attributes that should be present in a public open space. This will enable the park to meet users' needs and create a diversity of activities. As a result, Sudirman Park can become a successful public space in maintaining its sustainability. This optimization can be achieved by providing a variety of activity supports within the park that complement each other and the environment to generate vibrancy.

This study analyzes effective regional planning strategies for the sustainable development of rental villas in Lembang, focusing on environmental and social sustainability. Based on a survey of 311 tourists, it was found that 80% prefer environmentally friendly

DOI: http://doi.org/10.17509/jaz.v8i2.81556
p- ISSN 2621-1610 e- ISSN 2620-9934

accommodations integrated with nature, and show strong preferences for renewable energy use (65%), efficient waste management (70%), and environmentally friendly building materials (75%). This indicates a high level of tourist awareness of the importance of sustainability in accommodation choices. On the other hand, interviews with 10 to 15 local stakeholders, such as villa owners, tourism managers, and local communities, revealed that 70% believe good planning in rental villa development can enhance tourist experiences while minimizing negative impacts on local communities. Active community involvement in planning and managing villas has also proven beneficial in improving their economic welfare and creating authentic experiences for tourists.

Environmentally sensitive management that respects local culture also proves to be an important factor in increasing tourism appeal. Alongside this, proper zoning in land use management in Lembang is crucial to maintaining a balance between economic development and environmental preservation. Well-planned zoning allows for efficient management, reduces pressure on local ecosystems, and minimizes the negative impacts of rapid urbanization. This aligns with sustainability-based regional development that emphasizes nature conservation and improved quality of life for local communities. Furthermore, this study shows that environmentally friendly technologies, such as renewable energy systems and efficient waste management, have the potential to increase operational efficiency of rental villas while supporting long-term sustainability in the tourism sector. If implemented properly, these technologies can strengthen Lembang's competitiveness as a sustainable tourism destination and enrich the experience of environmentally conscious tourists.

This study has limitations regarding the sample scope, which only includes tourists staying in rental villas in Lembang. With a limited number of respondents, the study does not fully represent the dynamics of all tourists visiting Lembang. Additionally, although perspectives from local stakeholders were explored, the long-term social and economic impacts of tourism on local communities still require further examination. Further research is recommended to assess the long-term impacts of rental villa development on the socio-economic life of local communities in Lembang. This is important to understand how villa development can create sustainable economic benefits while preserving cultural heritage and increasing active community participation in tourism management. Research into the application of advanced technologies in villa construction, such as 3D Concrete Printing (3DCP) and technology-based waste management systems, could also open new insights into enhancing tourism sustainability in Lembang.

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