

Adaptation of Minahasan architectural local wisdom to thermal comfort in resorts on Bangka Island

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| ARTICLE INFO | ABSTRACT |
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| <p><i>Article history:</i> Received June 04, 2025 Received in revised form Oct. 07, 2025 Accepted October 31, 2025 Available online December 01, 2025</p> <p><i>Keywords:</i> Coral eye Local wisdom Thermal comfort Traditional Minahasa architecture Tropical climate</p> <p>*Corresponding author: Leidy Magrid Rompas Postgraduate Program, Universitas Sam Ratulangi, Manado, Indonesia Email: leidymagrid@unsrat.a.com ORCID: https://orcid.org/0009-0009-5339-6743</p> | <p>Bangka Island has challenges in tropical climate development such as limitations in the selection of efficient materials and energy, thus requiring a building concept that is adaptive to the climate. The Coral Eye Resort on Bangka Island is a building with a modern concept that adapts the local wisdom of Minahasa architecture to its building. The adaptation of traditional architecture to modern buildings is adaptive to the tropical climate because it can affect the thermal comfort of the building. This study aims to evaluate how the principles of local wisdom of Minahasa traditional architecture affect thermal comfort passively. This study uses a qualitative method with a case study approach to examine design elements such as building orientation and shape, local materials, openings, and spatial layout through observation techniques. Thermal comfort is tested through user perceptions collected through in-depth interviews, replacing the quantitative approach generally used in research related to thermal comfort. The results of the study indicate that the application of the principles of local wisdom of Minahasa traditional architecture, such as high roofs, large openings, and the use of local materials has an impact on increasing thermal comfort felt by users. The findings of this study provide insight into the implications of the theory of adaptation of Minahasa Traditional Architecture to thermal comfort in the context of modern buildings in coastal areas.</p> |

Introduction

Bangka Island, located along the coast of North Sulawesi, has a tropical climate influenced by its geographical and environmental conditions. Climate change in this region has become a serious challenge that affects various aspects of life, including architecture (Permatasari 2024). In the context of architectural design, climate is a key determinant of residents' adaptive behavior (Hermawan, Prianto, and Setyowati 2018). Therefore, harmony between human needs, natural conditions, and the local weather and climate must be taken into account in architectural design (Zain and Oktafiansyah 2023). By

understanding climatic conditions, it is possible to determine the appropriate architectural approach (Diwari and Setijanti 2016).

Buildings on small islands such as Bangka often face limitations in material selection and energy efficiency, thus requiring environmentally friendly solutions that are adaptive to local climate conditions (Müller 2020). In coastal areas, common challenges include excessive heat, high humidity, and strong winds. Passive control strategies, such as improved design, appropriate material selection, and passive solar features derived from vernacular architecture, can be adapted into modern construction (Chandel, Sharma, and Marwah 2016). Building orientation

also influences comfort by reducing direct solar radiation and enhancing natural ventilation (Faris and Nurhadi 2017).

The Coral Eye Resort on Bangka Island faces similar challenges in maintaining thermal comfort. Thermal comfort is a psychological condition that expresses satisfaction with the thermal environment (Santoso 2012) and represents an integral part of human interaction with the surrounding environment (Munawaroh and Elbes 2019). High temperatures and humidity levels often create a feeling of stuffiness. The resort adopts the local wisdom of traditional architecture, combining it with modern forms and materials. Cultural values representing local wisdom help shape the identity of coastal architecture (Fauzy 2012), where human elements, mindset, and natural conditions serve as the main driving forces (Soedigdo, Harysakti, and Usop 2014). Understanding local culture is essential to preserve traditions and local uniqueness (Susilo 2014), as traditional architecture functions as a container of community life (Aprita and Anisa 2020) and a manifestation of local wisdom (Zalukhu 2021).

Traditional Minahasan architecture demonstrates climatic adaptability through orientation, openings, and the use of local materials (Poli and Resosumarto 2024). Traditional materials are well-suited to climatic conditions (Beccali et al. 2018), improve insulation, and reduce the carbon footprint (Muh. Ilmiansah et al. 2025). The use of local materials also supports environmental, economic, and cultural sustainability (Mustafa 2024). Material innovation is necessary to protect communities from thermal stress (Latha, Darshana, and Venugopal 2015). Furthermore, appropriate openings, wind orientation, and the use of local materials play crucial roles in ensuring comfort (Roulus 2025). Traditional architectural principles can even be integrated with modern construction techniques such as concrete (Nursaniah, Izziah, and Qadri 2017).

The core problem of this study lies in determining the extent to which the adaptation of traditional Minahasan architecture implemented in the Coral Eye Resort enhances users' thermal comfort while maintaining local identity. This research is significant as it aims to strengthen the concept of humid tropical architecture (Hardiman 2012) and promote the application of sustainable design principles in coastal regions.

The hypothesis of this study posits that the adaptation of traditional Minahasan architectural principles can enhance thermal comfort and reinforce local architectural identity through building orientation, openings, and the use of local materials. Thus, this research contributes to the development of sustainable, energy-efficient tropical coastal architecture rooted in local wisdom.

Methods

Gosal (2012) demonstrated that traditional and wooden Minahasan houses meet the criteria for green buildings and provide thermal comfort, while Rondonuwu (2024) affirmed that traditional Minahasan architecture retains its fundamental characteristics even as it adapts to its surrounding environment. Building upon these findings, this study emphasizes the importance of examining how traditional Minahasan architectural principles can be adapted to modern resort architecture within the increasingly dynamic context of tropical climates.

The research employs a qualitative methodology, which is appropriate for addressing "how" and "why" questions (Yin 2009). A case study was conducted on the Coral Eye Resort, focusing on users' perceptions of thermal comfort. This approach was chosen because thermal comfort is a subjective experience that cannot always be accurately captured through quantitative data such as temperature, humidity, or wind speed. By exploring users' direct perceptions, this study seeks to understand how thermal comfort is interpreted within the spatial context of a modern resort that integrates local architectural wisdom.

Data collection involved several stages: (1) documentation and observation of adapted architectural elements derived from traditional Minahasan design; (2) in-depth interviews with resort users, the majority of whom (83%) are foreign visitors from temperate to cold climates, along with a smaller number of domestic guests and staff; (3) data analysis through categorization of architectural elements affecting thermal comfort; (4) triangulation of observations and interview results; and (5) synthesis and descriptive presentation of findings.

Before the analysis phase, the study recorded microclimatic data at several spatial points using

simple measurement tools, covering air temperature (26–32 °C), relative humidity (70–85%), and wind speed (0,2–0,8 m/s). These measurements revealed variations that support the interpretation of users' perceptions, where most participants reported feeling comfortable despite the physical indicators showing the hot and humid characteristics typical of tropical climates.

The state of the art of this study lies in its focus on the adaptation of traditional Minahasan architecture in modern resort design, emphasizing users' perceptions rather than solely technical parameters. The novelty of this research lies in connecting traditional Minahasan architectural principles with both foreign and local users' perceptions in the context of a modern resort. This provides new insights into the adaptation of local wisdom to thermal comfort, highlighting not only its technical dimensions but also its socio-cultural significance.

Results and discussion

Adaptation of Minahasan traditional architectural local wisdom in the Coral Eye Resort, Bangka island

The adaptation of Minahasan traditional architectural local wisdom in the Coral Eye Resort refers to the integration of traditional knowledge and construction practices into the building process, as well as the application of Minahasan architectural design principles and elements to enhance comfort while responding to the climatic conditions of a small coastal island environment.

Building form and spatial layout

Figure 1 shows that the main building has an elongated form, high ceilings, exposed structures, and open spaces without permanent partitions. This reflects local Minahasan concepts that emphasize the use of natural materials such as wood for structural elements that are sturdy yet allow free air circulation. This architectural character adapts the structure of traditional Minahasan houses, which have flexible spatial divisions and large air volumes that contribute to the creation of thermal comfort within the building.



Figure 1. Main building form of Coral Eye resort

Figure 2 illustrates the villa building form at the Coral Eye Resort. The villas embody an integration of modern architecture with local wisdom. The modern building form adopts traditional roof structures made from natural materials, such as rumbia or thatch leaves, which function to provide natural ventilation and protection from direct sunlight, thus enhancing indoor coolness. The high, curved roof form echoes the roof structure of traditional Minahasan houses, evoking a sense of peace and tranquility while facilitating optimal airflow within the space.



Figure 2. Villa building form of Coral Eye resort

The exterior employs natural materials such as wood and stone, creating harmony with the surrounding environment. The arrangement of open spaces and spacious terraces facing the garden reflects a close relationship with nature, accommodating the traditional architectural principle that values the connection between domestic space and the natural environment. This also mirrors the traditional concept of Minahasan houses, which feature open spaces integrated with their surroundings.

In the villa's interior (figure 3), the spatial layout appears simple and open, featuring warm

wooden flooring and concrete walls with natural textures that highlight the beauty of local materials. A lounge area is integrated with the bedroom, and each villa includes a private bathroom (figure 4). The humid bathroom space uses ceramic tiles on the floor and walls, and it connects directly to an outdoor area enclosed by a high concrete fence to ensure privacy and security. The high ceiling and natural materials used in the interior create a cool and comfortable atmosphere, reflecting the traditional architectural principle that prioritizes thermal comfort. Natural ventilation systems, such as large windows that allow air to flow freely, represent an adaptation of traditional house concepts that ensure the comfort of occupants.

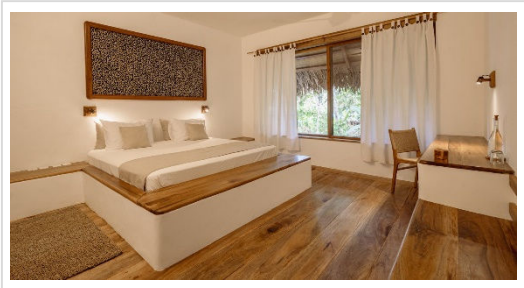


Figure 3. Interior of villa building, Coral Eye resort



Figure 4. Interior of villa building, Coral Eye resort

These villas also integrate modern functional elements with minimalist aesthetics, maintaining a balance between visual beauty and functional comfort. This approach aligns with traditional architectural principles that emphasize equilibrium and resilience in tropical climates.

Construction techniques and use of local materials
The structural system of the Coral Eye Resort exhibits a post-and-beam timber construction resembling the joint techniques used in

Minahasan stilt houses (figure 5). This structure not only strengthens the tropical visual character but also improves ventilation beneath the floor, reduces humidity, and helps control indoor temperature through passive means.

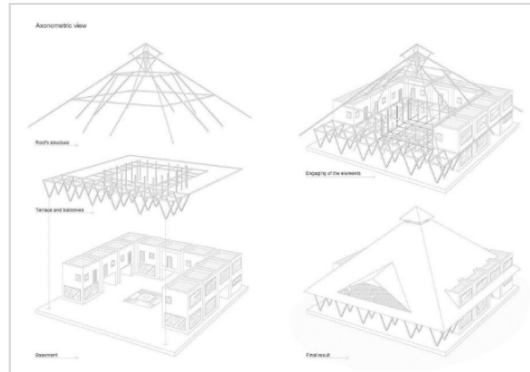


Figure 5. Construction of the main resort building

The interior of the main Coral Eye Resort building (figure 6) combines traditional and modern elements through the use of timber beams and robust metal supports, creating a visually spacious, open, and clean impression. The slanted columns form a triangular frame, functioning not only as structural supports but also as aesthetic elements that reinforce the spatial character. The design expresses stability, strength, and visual appeal while maintaining a connection with traditional Minahasan architecture, thus providing a sense of comfort for users.



Figure 6. Interior space of the main resort building

The main building utilizes local materials such as tropical hardwoods, bamboo, rumbia leaves, and other natural materials with good thermal insulation properties. The flooring uses ceramic tiles, a feature common in modern buildings, providing comfort for visitors walking barefoot indoors. This material combination creates effective thermal performance without sacrificing aesthetic and cultural values, as the structural

joints were crafted by Minahasan carpenters. Several column and beam joints use traditional wooden pegs or dowels (figure 7), connecting two elements by overlapping their ends. Material selection in the resort follows Minahasan architectural principles that employ lightweight woods such as cempaka, which help stabilize indoor temperatures and respond gradually to outdoor temperature changes. The use of natural materials ensures good air circulation and reduces the greenhouse effect.



Figure 7. Wooden structural joint of the main resort building

The resort's roof adopts a steep gable form with extended overhangs, effectively dissipating heat while protecting the building from direct sunlight (figure 8). The roofing material uses tightly woven rumbia leaves that allow natural air circulation while maintaining a traditional appearance. Meanwhile, the use of ijuk (palm fiber) enhances aesthetic and cultural identity, though it is more fire-prone, particularly in tropical coastal climates. This reinterpretation highlights the interrelation between roof form, natural materials, thermal performance, spatial comfort, and the visual expression of local culture.



Figure 8. Roof form and materials of the main resort building

The figures above demonstrate the application of traditional Minahasan principles, particularly in the use of wood as the primary material and in the structural elements columns, beams, and open roof systems of the resort buildings. Traditional Minahasan architecture relies on natural materials that are strong, durable, and adaptable to the hot and humid tropical climate. The emphasis on thermal comfort in Minahasan house concepts is also evident in these buildings, where natural ventilation and the use of materials such as timber and rumbia roofing contribute to a cool and comfortable atmosphere for users.

Building orientation and ventilation

Figure 9 displays the seaside view from the villas of the Coral Eye Resort, where all buildings are oriented directly toward the sea. This orientation not only provides aesthetic value but also reflects Minahasan architectural wisdom, which situates buildings in harmony with natural surroundings. The position of the villas and main building responds to the prevailing sea breezes, serving as a natural ventilation source. Large openings on the building sides maximize the entry of sea winds, enabling passive cooling, improving air circulation, and ensuring thermal comfort appropriate to the tropical coastal climate.



Figure 9. Ocean view from the front of Coral Eye resort villa

The villa buildings oriented toward the beach connect indoor and outdoor spaces through large window and door openings ([figure 10](#)). These wide openings maximize landscape views around the resort. However, due to extreme temperatures sometimes experienced in coastal regions, particularly during the dry season, the villas are equipped with artificial cooling systems such as air conditioning. This hybrid approach combining natural ventilation with artificial cooling ensures that indoor comfort is maintained even under the highest heat conditions.



Figure 10. Interior of Coral Eye resort villa with large openings

The main building of the Coral Eye Resort also adopts a design that emphasizes openness, relying on the absence of solid walls in many areas. As observed in previous figures, this large open structure serves as a key element in facilitating natural ventilation. The building's orientation is carefully planned to take advantage of coastal winds and the outdoor climate. Large windows, doors, and the absence of traditional walls allow unobstructed airflow, which is crucial in tropical settings where interior spaces can quickly accumulate heat and humidity.

The main resort building is designed with minimal internal partitions and visually emphasizes aesthetically crafted wooden column structures. This approach ensures that sea breezes can freely circulate through the interior, enhancing natural airflow into the building, as shown in [figure 11](#).

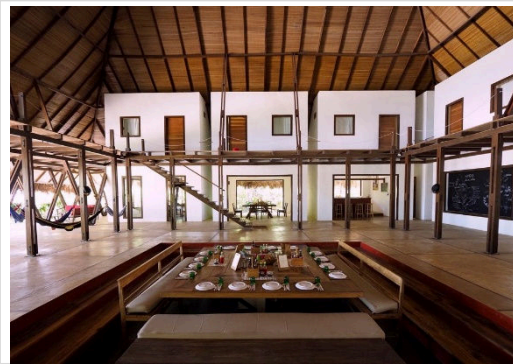


Figure 11. Interior of the main building, Coral Eye resort

Both the main building and the villas illustrate a modern approach integrated with traditional Minahasan tropical architecture. The sea-facing orientation and the open-plan design that maximizes natural ventilation are essential strategies for coastal areas, particularly on small islands like Bangka, where energy resources are limited. By reducing reliance on mechanical ventilation for passive cooling, both the beachfront villas and the main building of the Coral Eye Resort can be considered energy-efficient structures that enhance user comfort in a tropical coastal environment.

Spatial utilization

[Figure 12](#) presents the site plan of the Coral Eye Resort, demonstrating the adaptation of Minahasan architectural principles. The main building is centrally located, surrounded by

supporting villas. The main hall is designed as an open and spacious area, similar to traditional Minahasan houses, which provide large communal spaces for families. This spatial concept promotes flexible circulation and close social interaction, reflecting Minahasan local wisdom that emphasizes togetherness, interfamily relationships, and community connectedness in daily life.

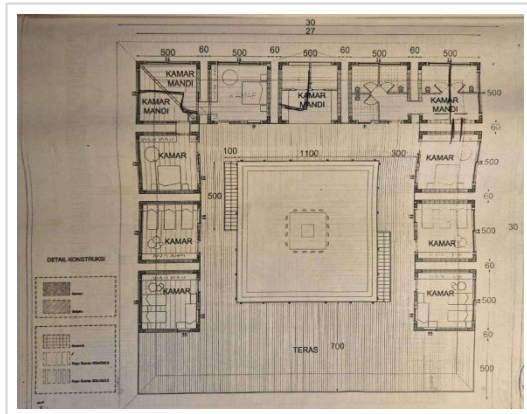


Figure 12. Site plan of Coral Eye resort

The villas surrounding the main building adopt spatial planning principles based on the separation of public and private areas, similar to the spatial organization found in traditional Minahasa houses, which prioritize family privacy within spaces distinct from communal activity areas. Each villa is equipped with separate bedrooms and bathrooms; a concept aligned with the Minahasa cultural values regarding privacy in personal spaces. Furthermore, the expansive terraces in the villas demonstrate an adaptation to local wisdom that leverages the tropical climate, creating comfortable outdoor spaces for relaxation, both for interaction among guests and for enjoying natural views.

Sustainable adaptation

Sustainable adaptation at Coral Eye Resort on Bangka Island reflects the integration of environmentally friendly principles with Minahasa local wisdom. The buildings follow the natural contours of the land, employing short-pile foundations akin to stilt houses to respond to sloping and humid terrain, while minimizing the use of concrete and vegetation intervention. The design prioritizes natural ventilation, building orientation aligned with the tropical climate, and the use of local materials, thus achieving energy efficiency while maintaining thermal comfort. This approach illustrates how traditional Minahasa architecture can be adapted in a modern context to preserve cultural identity, respect the environment, and meet sustainability requirements without compromising user comfort.

Thermal comfort at Coral Eye resort on Bangka Island based on user perception

User perception of air circulation and natural ventilation

The diagram in [figure 13](#) shows the results of a survey at Coral Eye Resort on Bangka Island, indicating that the majority of users (87%) feel highly comfortable due to the design of cross ventilation, double openings, and high ceilings, which maintain cool indoor temperatures without extensive mechanical assistance. Approximately 11% feel moderately comfortable, particularly in areas with suboptimal ventilation or high humidity. Meanwhile, 2% reported discomfort, generally in enclosed spaces without cross ventilation, such as bathrooms and certain villas, where air conditioning is still required to achieve comfort.

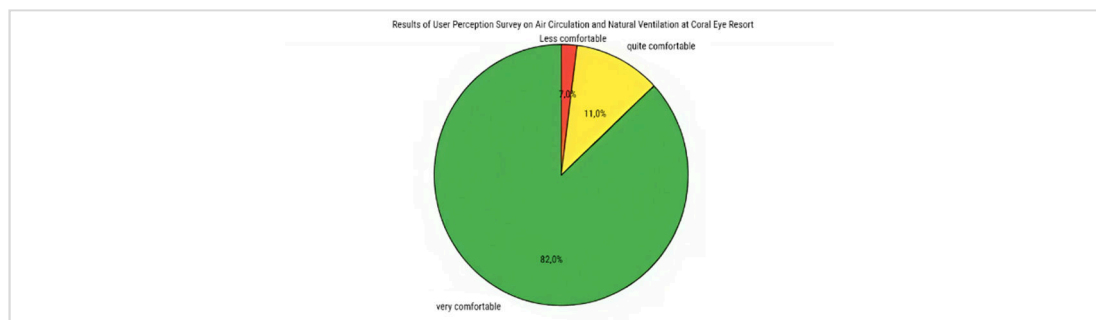


Figure 13. Survey results of user perception regarding air circulation and natural ventilation at Coral Eye resort, Bangka Island

User perception of natural lighting comfort

The diagram in Figure 14 presents survey results showing that 75% of respondents feel very comfortable with natural lighting, indicating that the building successfully optimizes Minahasa local wisdom. About 20% reported moderate

comfort, particularly in villa spaces with limited natural light that occasionally require supplemental lighting. Meanwhile, 5% felt discomfort due to spaces with minimal windows, such as stairwells or villas partially obstructed by the main building.

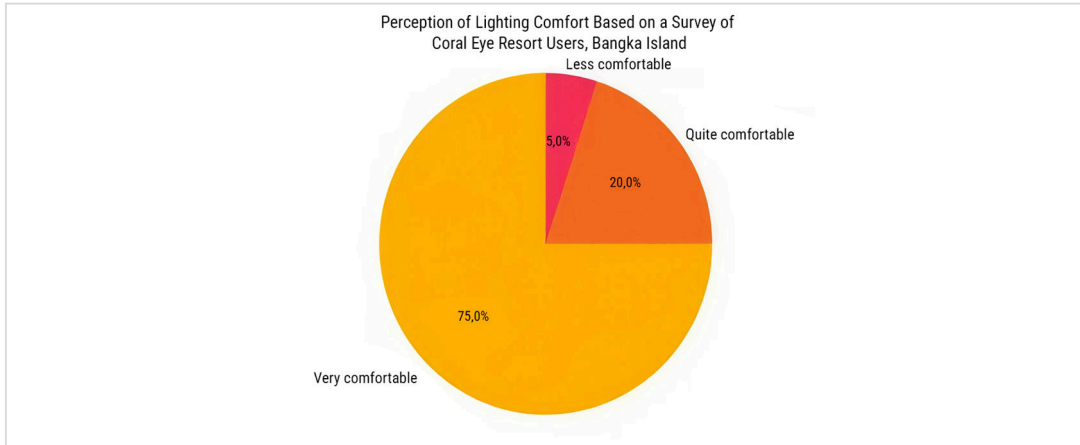


Figure 14. Diagram of user perception survey regarding natural lighting at Coral Eye resort buildings

User perception of material and construction comfort

The diagram in figure 15 shows that 55% of users feel very comfortable with natural lighting and ventilation, reflecting the application of Minahasa local wisdom. Forty percent rated the experience as moderately comfortable,

appreciating the wooden materials yet still feeling heat during certain hours and observing deterioration in wooden posts. Meanwhile, 5% expressed discomfort due to modern preferences, concerns over fire hazards in wooden buildings, and disturbances from wooden floor creaking in villa areas.

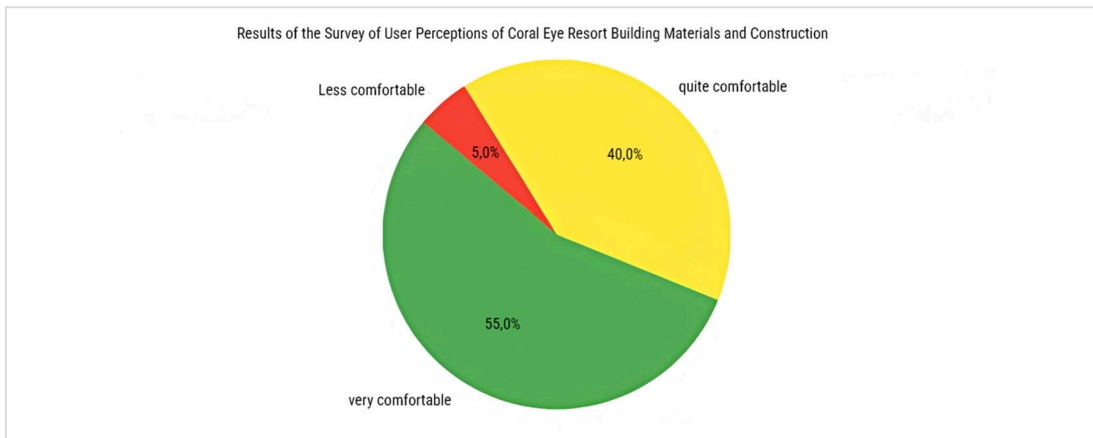


Figure 15. Diagram of user perception survey regarding material use and construction at Coral Eye Resort

Conclusions

The research findings indicate that the adaptation of traditional Minahasa architectural elements at Coral Eye Resort such as high conical roofs, large

openings, local materials (wood, bamboo, rumbia), and building orientation aligned with sea breezes significantly contributes to thermal comfort without relying on mechanical cooling. User perception surveys show that over 75% of

respondents feel very comfortable, although challenges with high humidity and uneven temperature distribution persist, leading some villas to still use air conditioning. Theoretically, this study affirms the relevance of tropical architecture concepts grounded in local wisdom as an energy-efficient, environmentally friendly, and culturally preserving passive design strategy.

The adaptation of traditional Minahasa architecture in both the main and villa buildings at Coral Eye Resort demonstrates how integrating local wisdom with modern construction principles can enhance energy efficiency, environmental sustainability, and user comfort. This approach allows modern public buildings to maintain cultural identity while strengthening their connection to the tropical climate and surrounding environment, ensuring that the resort remains rooted in local wisdom yet fully responsive to contemporary needs.

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Author(s) contribution

Leidy Magrid Rompas contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Jefrey I. Kindangen contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

Valeria Theresia Woy contribute to methodology, supervision, and validation.