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Study of Sustainable Aspect in the Mbaru Niang Traditional House in Wae Rebo Village, East Nusa Tenggara

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Abstract

This study examines the sustainability of the Mbaru Niang house in Wae Rebo Village, Indonesia, through a qualitative descriptive method. The analysis focuses on the spatial layout as well as supporting elements such as materials, climate responsiveness, and communal functions, using visual interpretation and thematic mapping based on environmental, social, and well-being dimensions. The findings reveal how the use of local materials, passive ventilation, communal spatial organization, and flexible design strategies reflect an integrated approach to sustainability. Mbaru Niang demonstrates how traditional architecture, grounded in ecological adaptation and cultural continuity, can inform contemporary sustainable design. While the study is limited by its reliance on secondary data and scope, it contributes to architectural discourse by emphasizing the value of traditional knowledge in creating resilient and context-sensitive built environments.

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INTRODUCTION

Global warming which caused by human activities has become a primary catalyst for ongoing climate change (Houghton, 2001). In response, efforts to reduce energy consumption and mitigate the impact of population growth have become increasingly urgent, making awareness of sustainable design more critical than ever (Masood et al., 2017). In this context, sustainable architecture offers a vital approach. According to Sassi (2006), sustainability in modern architectural design can be achieved through measurable parameters such as land use, community integration, health and well-being, material selection, and efficient use of water and energy. While these parameters are often framed for contemporary applications, many of them have long existed within traditional architecture (Puspita et al., 2025). In the face of rapid urbanization and modern development that often neglects traditional ecological wisdom, sustainable design should integrate time-tested vernacular techniques that respect nature and incorporate renewable energy sources (Todorovic et al., 2011). Such integration fosters harmony between the built environment and its natural surroundings.

Recent discussions on sustainability in architecture have largely focused on green building practices, especially in urban contexts. While this focus is essential, it often lacks sufficient engagement with traditional architectural systems that inherently embody sustainable values. Nabilunnuha et al. (2022) highlight the importance of sustainable architecture in preserving natural resources and ensuring long-term environmental resilience in future developments. Meanwhile, Sokienah (2020) argues that academic discourse surrounding sustainability still shows a weak response when it comes to exploring its application in traditional architecture. Although certain traditional practices reflect sustainability principles, scholarly literature examining how these values are embodied in Indonesian vernacular houses remains limited (Puspita et al., 2025). For instance, Puspita's study on the Osing house in Kemiren, Banyuwangi, demonstrates how traditional building techniques and material use are inherently aligned with sustainable principles, particularly through climate responsiveness and local wisdom.

Iwamura (2003) highlights the importance of responsive design, which refers to architecture that adapts to local conditions by using sustainable materials and promoting energy efficiency. His framework promotes harmony with nature and supports occupant well-being by minimizing environmental impact and maximizing local resource use.

The framework has been widely applied in the studies of Japanese and contemporary architecture. However, its application in the context of Indonesian vernacular houses remains rare. This study thus contributes a perspective by using Iwamura's framework to analyze traditional Indonesian architecture, demonstrating how spatial organization, material choices, and cultural values in structures like the Mbaru Niang embody sustainability principles.

While Sassi (2006)'s framework provides a useful set of parameters for assessing sustainable performance in modern architecture, it often lacks sensitivity to the cultural and social contexts of traditional dwellings. In contrast, Iwamura's framework, which consists of *Low Impact*, *High Contact*, and *Health & Amenity*, offers well-rounded perspective and is especially relevant for evaluating vernacular structures such as the Mbaru Niang in Wae Rebo. By studying traditional architecture, which is inherently adapted to local climates and built on environmentally responsive principles, we can obtain meaningful insights to inform contemporary sustainable design practices.

This study focuses on the floor plan as well as supporting elements such as materials, climate responsiveness, and communal functions of the Mbaru Niang house, analyzed through the lens of Iwamura's theory. In the traditional Wae Rebo context, spatial divisions are not merely functional, but symbolically reflect kinship, ritual order, and communal living (Pandjaitan & Ellisa, 2014). By analyzing the floor plan and another supporting elements, this study captures how sustainability values manifest through spatial organization, including shared use of resources, privacy, and social cohesion. While other architectural elements such as material use, structural systems, or thermal performance also contribute to sustainability, this research narrows its analytical scope to spatial layout in order to provide clarity and depth. Future studies are encouraged to explore these additional aspects to complement the current findings.

LITERATURE REVIEW

Iwamura's Theory of Sustainable Architecture

Sustainable architecture is architecture that meets present needs without compromising the ability of future generations to meet their own needs, where these needs vary from one society to another, from one region to another, and are best determined by the concerned community (Steele, 1997). Iwamura (2003) outlines several aspects that must be considered to realize the concept of sustainability, as illustrated in **Figure 1**.

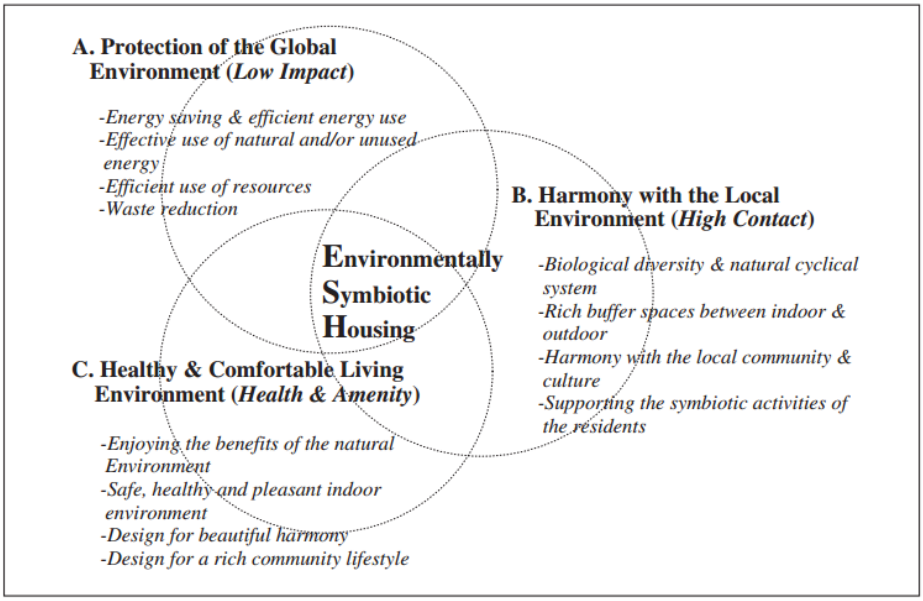


Figure 1. Diagram of Three Basic Goals for Achieving ESH (Environmentally Symbiotic Housing) (Source: Iwamura, 2003)

The three basic goals, referred as Environmentally Symbiotic Housing (ESH), aim to preserve the global environment by saving energy and resources while reducing waste (Iwamura, 2003). The first point of ESH includes *Low Impact*, which relates to values associated with how to preserve the environment and natural resources, as well as the impact of housing, such as air quality, land availability/use, attitudes toward plants, attitudes toward other animals, responses to climate, and reducing the impact of buildings on the environment, such as energy savings and effective utilization of natural resources. Low Impact includes energy conservation and minimal waste production in various ways and levels.

The second goal is *High Contact*, which relates to human values, such as how humans are connected as individuals, the meanings within a family and community, and the norms that influence an element of traditional architecture or even shape the influence of the city scale/spatial hierarchy. *High Contact* also refers to the relationship between the building and its environment, light, water, air, and organisms. This goal includes biotopes that accommodate plants and animals and provide gathering spaces as part of a lifestyle, appreciating the tradition of togetherness. It emphasizes how development should align with history, landscape, the site's inhabitants, and the surrounding areas affected by the type of community established there.

The final point is *Health & Amenity*, which discusses how a building can influence the culture and health of its inhabitants, both when the building is being constructed and once it is inhabited. It can be achieved both physically and mentally, with an emphasis on two key points. The first point is '*be safe'*, related to the physical health of the occupants, where design can expose humans to a healthy and comfortable environment. The other one is '*feel safe'*, related to the comfort of the occupants, ensuring no issues or discomfort arise later, with flexible design, through the building itself or the daily lives of its inhabitants.

An important point to consider in this ESH is the importance of understanding and utilizing stakeholder values to ensure a scheme's feasibility and social compatibility. Buildings play a role in building local identity (Fernandes et al., 2015; Iswanto et al., 2022; Putri et al., 2023). At the same time, the success of environmental technologies depends not only on technical efficiency but also on social support, which can be fostered through a bottom-up approach involving community consultation and participation in the phases of the design process (Arboleda, 2020). The process should be informed by the community's contextual characteristics, enabling adaptation to local social and environmental concerns through inclusive engagement and continuous feedback mechanisms (Adib, 2021). Operations and maintenance must be considered and aligned with available resources (Correia et al., 2014). An integrated approach to social, ecological, and building issues can still be achieved within budget constraints. (Iwamura, 2003) provides examples of houses that successfully support ESH, such as the Fukusawa Symbiotic Housing Complex, where the house design and layout do not interfere with water flow, preserve surrounding trees, capture the potential benefits of seasonal winds, and even connect with regional ecological habitats.

Characteristics of the Mbaru Niang Traditional House

Mbaru Niang is a traditional house in the Wae Rebo village, a cultural village in West Manggarai, East Nusa Tenggara. Wae Rebo village is about 1,120 meters above sea level, surrounded by mountains and dense forests, and is far from other settlements. There are only seven Mbaru Niang houses, each inhabited by seven families from different tribes. The seven Mbaru Niang houses, built by their ancestors, represent the seven cardinal directions of the mountain peaks that surround Wae Rebo village (see **Figure 2**, left), namely *Ulu Wae Rebo*, *Golo Mehe*, *Hembel*, *Golo Ponto*, *Ponto Nao*, *Rendang*, and *Polo*.

All Mbaru Niang houses are built on flat land and arranged around an altar known as "*Compang*", which serves as the central point of these seven houses. It is believed to be the most sacred structure and an altar for honoring and worshiping God and the spirits of the ancestors. The Mbaru Niang, which follows the concept of macro cosmos, consists of three parts: the lower space (*kolong*), commonly referred to as the feet; the middle space (*badan*), which is the area where human activities take place; and the upper space (*kepala*), which is the roof area. The upper space is linked to beliefs in their ancestors and God.

The lower space in the Mbaru Niang is the area beneath the building where livestock are kept, and during the day, women often weave on the edges of this space. The middle space is where human activities occur, where the rooms for each family, the kitchen, and a guest area are located. The first floor is divided into private and public spaces, separated by a stove in the middle of the room. Women typically work in the kitchen or around the stove, while men usually gather in the front, near the entrance. This middle space is supported by nine main pillars, which form the structural concept of the Mbaru Niang itself, and these pillars are separated from the floor above them. The upper space/roof consists of four levels.

These spaces are unified by a central pillar, one of the main pillars. This pillar extends from the bottom to the top or peak of the building. The people of Wae Rebo consider the central pillar sacred due to its function as the axis of the building. Inside the Mbaru Niang, the central pillar is the focal point, with all activities directed towards it. For example, people position their bodies facing the central pillar when sleeping. Additionally, during gatherings inside the Mbaru Niang, the community sits in a circle, with the village elder positioned in front of the pillar, facing the entrance.

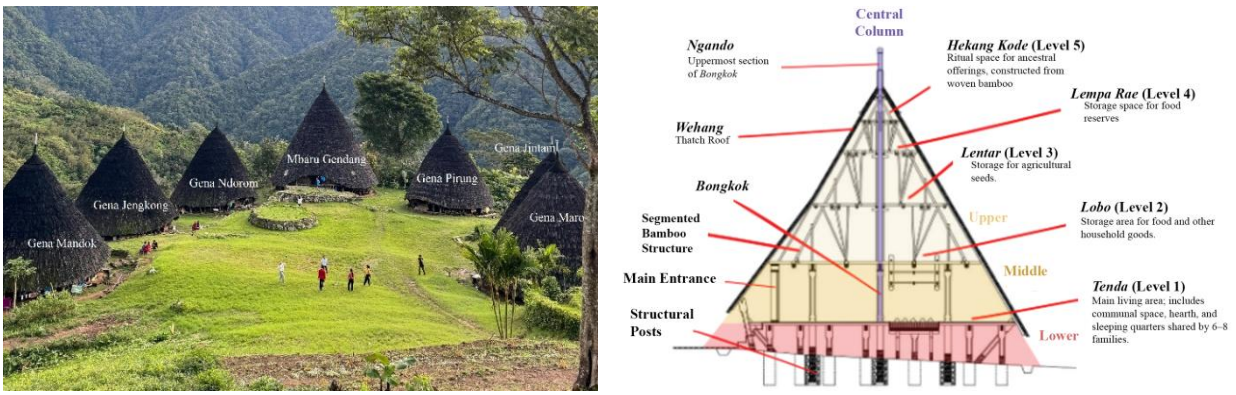


Figure 2. Illustration of Seven Mbaru Niang Houses (left), Concept of Space in Mbaru Niang (right) (Source: modified from Pinassang et al., 2021)

Elements and Materials

The Mbaru Niang house has forming elements resulting from the configuration of various materials. According to Krier (1992), the architectural elements that support the structure of the building are the roof, walls, floor, door, and windows.

The roof is circular and narrow as it rises (cone-shaped). It is inspired by the structure of a spider's web, with the center of the web being pulled upwards (Louis, 2015). The roof material of Mbaru Niang uses two layers of materials: *ijuk* (palm fibers) and *alang-alang* (grass). There are 325 strands of *ijuk* and *alang-alang* as the roofing material for Mbaru Niang. The roof also serves as the dominant wall in Mbaru Niang, with the remaining walls made of wooden planks located at the entrance and as dividers between rooms for each of the eight families. The walls of Mbaru Niang are plain and do not finish. The wooden planks are erected, and several planks at the front of the entrance have a particular slope with varying lengths.

The traditional Mbaru Niang house has many columns supporting the building's structure (main pillars, or *Siri Bongko*). These columns are made from solid, unjointed wood, with the wood used being about 70 years old. On the *Siri Bongko*, there is a ladder leading to the next floor, and the length of the ladder is the same as the height of the central pillar made from *worok* wood. Bamboo, tied and aligned vertically, forms a robust ladder capable of bearing the weight of an adult male.

The floor uses wooden planks that are strong enough to support the weight of many occupants (around 12–16 people). The planks are supported by the building structure with a stacking system and reinforced with rugged and strong wood stakes. Wooden planks now employ nail construction in the Mbaru Niang traditional house after its renovation because the community is concerned for the forest. The people of Wae Rebo decided to use nails and cut down trees, distributing the wooden planks for the floor. Their concern for the surrounding nature led the community to replant the trees used in the construction of the house to prevent further damage to the surrounding forest.

The single door in the Mbaru Niang house uses wooden planks without finishing, without hinges, and is locked using a bar that serves as a stopper at the door handle. The windows (*paratonggang*) are limited to four, with small openings. Due to the cold climate and the fact that most of the inhabitants' activities occur outdoors (from morning until late afternoon), there is no need for maximum lighting. The windows are open, supported by small wooden rods inside the house. The natural light entering through the openings changes position with the sun's movement, creating a dynamic effect of light that brightens the house's interior.

(a) (b)

(c)



(d)



(e)

Figure 3. Elements and Materials that Constitute Mbaru Niang's House: (a) Floor; (b) Walls and Roof; (c) Column; (d) Door; (e) Windows.
(Source: Louis, 2015)

The facade of the Niang house is visually dominated by its thatched exterior, which fully envelops the conical structure (See **Table 1**). The only prominent architectural feature is the main entrance, which is defined by a slightly protruding arched opening.

Table 1. Characteristics of the Mbaru Niang façade

Facade	Form	Structure	Material
Floor	 The first floor has a diameter of 11 meters and serves as the main floor where the community's activities take place. It is constructed after the foundation is completed. The floor is supported by beams and wooden planks, and is surrounded by large rattan logs that serve as the main supports for the roof.	 The foundation of the Mbaru Niang house consists of several wooden logs planted into the ground to a depth of 2 meters. The wood may decay due to moisture or become brittle, which weakens its ability to support the entire structure of the house.	The floor material consists of 2 cm thick planks. The floor is made of *ajang* wood planks that are arranged parallel and tightly installed.
Wall	 The walls are made of bamboo cladding in a conical shape. There are four window openings to facilitate air exchange.	 The wall construction is made of continuous bamboo (*buku*).	Bamboo is tied with rattan and covered with *ijuk* and *lontar* leaves.
Body/ Roof	 The roof is cone-shaped and merges with the body of the building. The roof is supported by the main pillar using a pin system and is made of *worok* wood that is 70 years old.	 The roof construction extends continuously from the floor to the roof. It is formed from bamboo that is assembled in a conical shape and supported by 9 pillars with a height of 15 meters.	Both the roof and walls use the same materials: bamboo, rattan, *ijuk*, and *lontar* leaves, as the body of the Niang house and its roof form a unified structure.

Facade	Form	Structure	Material
Door	 There are two doors on the Niang house: a front door and a back door. The front door is semicircular, following the shape of the building's body, and slightly protrudes outward from the building's body.	 The structure is made of bamboo that curves to form the door.	The main door is made from a bamboo structure without covering, while the back door uses wooden planks as the material.
Windows	 The windows, called *paratonggang*, are rectangular in shape and there are four of them. They are located in several parts of the Niang house and serve as a source of ventilation and natural lighting.	The window is supported by a bamboo frame in a rectangular shape, measuring 30x30 cm.	It is composed of a bamboo frame.
Facade	 The facade covers the entire building and forms a cone shape in accordance with the framework structure.	The facade is made of dried *ijuk* and *alang-alang*, which are tied to rattan that circles and binds the bamboo clumps forming the structural body of the building.	The building facade is covered with *alang-alang* and *ijuk* that are tied to the bamboo joints using rattan, and it has a dark brown to yellowish color.

Source: Adapted from Dwiputri (2015), modified by the author (2024)

Spatial Arrangement

The Mbaru Niang house consists of five vertically arranged levels, each serving distinct functional and symbolic purposes (Lad, 2013; Louis, 2015; Pandjaitan & Ellisa, 2014). Each level serves specific roles, accommodating communal activities, storage needs, and cultural symbolism in a way that embodies the residents' connection to their environment and traditions.

The first level, known as *Lutur*, functions as the primary living space where communal and family activities take place. This level is divided into two zones: *Nolang*, the private area containing a communal hearth and sleeping quarters for 6–8 families that is arranged according to the birth order of each family head. The public zone, referred to as *Lutur*, is used for receiving guests and hosting community gatherings. The diameter of this level spans approximately 11 meters. Above it, the second level known as *Lobo*, serves as an attic for storing food and household necessities. It contains a suspended pillar shaped like a human head, symbolizing childbirth. This level measures around 9 meters in diameter.

The upper levels are primarily dedicated to storage and ritual functions. The third level, known as *Lentar*, is designated for storing agricultural seeds such as rice, corn, and legumes, with a diameter of 6 meters. Rising higher, the fourth level, *Lempa Rae*, functions as a reserve storage area for food supplies, particularly in anticipation of drought or harvest failure, and measures 3 meters across. At the very top, the fifth and smallest level, *Hekang Kode*, is reserved for ritual purposes, specifically for placing ceremonial offerings dedicated to ancestral spirits. It is constructed from woven bamboo and has a diameter of approximately 1.8 meters.

METHODS

This study employed a descriptive qualitative analysis to explore the sustainability aspects of the traditional Mbaru Niang house in Wae Rebo Village, Flores, East Nusa Tenggara. The research was conducted by analyzing secondary data, which were collected through a literature review of peer-reviewed journal articles, official architectural studies, and supporting visual materials such as site photographs and diagrams from reputable sources. While this approach enables the synthesis of diverse perspectives, it also presents inherent limitations. The absence of primary field data may affect the depth of contextual insights, and the study's findings depend on the quality and accuracy of the secondary sources used. To address this, only credible and academically recognized publications were selected to ensure methodological rigor.

This study began by identifying the components and characteristics of the Mbaru Niang house through a literature review, similar to the approach of Puspita et al. (2025) in the context of traditional houses with sustainable aspects. Subsequently, these components and characteristics were analyzed with a focus on the spatial configuration of the Mbaru Niang floor plan as well as supporting elements such as materials, climate responsiveness, and communal functions. The study applied Iwamura's ESH framework, which consists of three key principles: *Low Impact*, *High Contact*, and *Health & Amenity*.

The findings then synthesized by mapping these architectural characteristics against Iwamura's sustainability categories, aiming to assess how traditional spatial organization contributes to environmental, social, and occupant well-being dimensions of sustainable architecture. The principles proposed by Institute for Built Environment and Energy Conservation (1999) in Iwamura (2017) (see **Table 2**) serve as the analytical variables in this study. Each of the three main categories is represented by specific indicators. Under the Low Impact dimension, the analysis includes aspects such as energy conservation and the effective use of natural resources. The High Contact dimension is represented by the presence of biotopes and communal gathering spaces. The Health and Amenity dimension includes indicators such as physical safety '*be safe*' and the perception of safety for occupants *'feel safe*'. This exploration aims to provide insights into how sustainability (based on iwamura's principle) values manifest through Mbaru Niang house.

Table 2. Principles Proposed by Iwamura (2017)

Variables	Sub-Variables	Source
Low Impact	Energy Conservation	(Iwamura, 2017)
	Effective Natural Resources	
High Contact	Has a Biotope	
	Has a Gathering Space	
Health & Amenity	Be Safe	
	Feel Safe	

RESULTS AND DISCUSSION

Low Impact

The Low Impact category refers to indicators of environmental sustainability that relate to how a building interacts with natural resources, land use practices, local climate conditions, and its surrounding vegetation and wildlife. Within this category, two important aspects are particularly relevant for assessment: energy conservation and the effective use of natural resources.

Energy Conservation

Several aspects are considered part of energy conservation strategies, including natural lighting, thermal radiation control, natural ventilation, and the use of low-carbon emission materials. In terms of natural lighting, each Mbaru Niang building features four small openings that allow daylight to penetrate the interior spaces. Natural lighting contributes significantly in reducing energy consumption in buildings while simultaneously enhancing occupant comfort and supporting human health (Gago et al., 2015). It's accommodated through the ceiling structure, functions primarily as a spatial component that allows light to enter and hang within the upper interior space (Louis, 2015). Although these traditional houses rely on daylight as a primary source of illumination to support environmental sustainability, the overall daylight levels remain relatively low, resulting in dim interior conditions. Even so, artificial lighting in the form of lamps has been introduced to improve visibility indoors (Pandjaitan & Ellisa, 2014).

Figure 4. Illustration of Natural Lighting of Building (left), Building Windows (right)
(Source: (left) Adi Gunawan, (2021); (right) Photo by Edward V. Gunawan (2025), used with permission)

Regarding the roof structure, palm leaves and palm fibers (*ijuk*) are the primary materials used for the thatched roof, functioning as thermal insulation. Thatch provides effective thermal insulation by helping to retain heat during colder seasons and reduce heat gain during warmer periods (Pickles, 2016). In addition, palm fiber has been shown to possess strong thermal insulation properties, making it a sustainable alternative to conventional synthetic materials for building applications (Oushabi et al., 2015). The study by (Klaudia & Lapisa, 2019) demonstrates that *ijuk* fiber is a natural material capable of regulating indoor air temperature. Heat is absorbed by the ijuk fiber without being transmitted downward, thereby maintaining a stable and comfortable temperature during both daytime and nighttime (Lad, 2013). The overhang on the roof serves as an auxiliary canopy to prevent solar radiation.

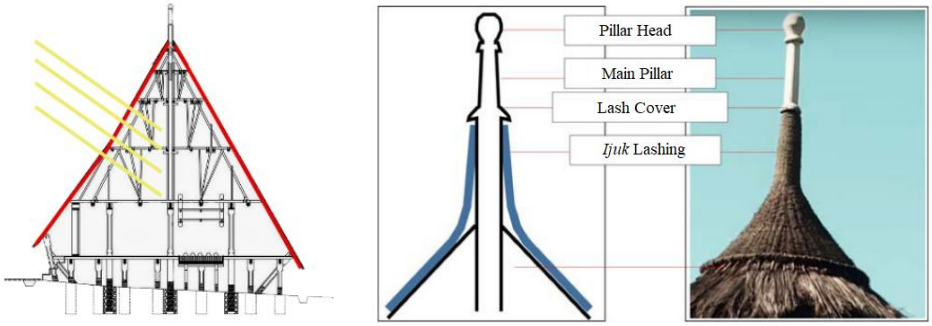


Figure 5. Illustration of Mbaru Niang Thermal Radiation Process (left), Overhang on the Roof (right)
(Source: (left) modified from Satwikasari, 2016; (right) Ariyanto, 2020)

As for natural ventilation, air flows through two main openings located at the front entrance and the back door, and is then distributed across the different levels of the structure. Natural materials such as palm leaves and fibers have a textured pattern that allows fresh air to enter. The thatched roof provides structural protection while simultaneously facilitating natural ventilation. Its conical form and breathable materials enable the upward movement and release of warm air through the roof apex, while cooler air is drawn in from lower-level openings, thereby supporting continuous passive airflow within the interior space (Lad, 2013).

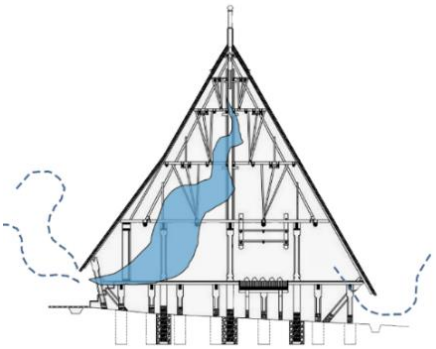


Figure 6. Illustration of Natural Ventilation of Buildings
(Source: modified from Satwikasari, 2016)

Building upon the passive cooling strategies achieved through natural ventilation, the architectural features of Mbaru Niang also contribute significantly to reducing environmental impact. Traditional houses embody cultural identity, reflecting the way of life and cultural expressions of a community. Their distinctiveness lies not only in the materials or textures used but also in how these elements are applied in daily life. Additionally, the materials used are more environmentally friendly as they are easily decomposable and biodegradable (Juwono, 2017) (see **Figure**

7a). However, the *alang-alang* (grass) used comes from Mules Island, a different island from Wae Rebo (see **Figure 7**b). To obtain this grass, ships and motor vehicles are required.Vernacular architecture is characterized by its adaptation to the local environment, responding to climatic and topographical conditions through the use of locally sourced materials, which helps to minimize environmental impact (Durukan et al., 2021). Because the natural materials used are sourced locally (from the surrounding forests) (Lad, 2013), the resources and materials at each stage of construction do not generate excessive environmental emissions.

(a) (b)

Figure 7. (a) Natural Materials that Produce Less Emissions into the Environment; (b) Distance Required to Obtain the Material (Source: (a) Juwono & Susanto, 2018; (b) Google Earth, 2024)

Effective Natural Resources

Vernacular architecture such as Mbaru Niang houses reflects the community's adaptive response to its environment, integrating local geography, culture, and lived experience to sustain harmony with nature (Fernandes et al., 2015). The area where Wae Rebo was estabilished was originally part of uninhabited forest land. Specific sites were later chosen based on their relatively level topography, which made the more suitable for building. All the surrounding trees were cut down and used to build the 7 Mbaru Niang houses. With the growing needs of the Wae Rebo community, new buildings began to emerge. The initial process of selecting the location for these new buildings remains the same as in the past (see **Figure 2**, left).

Mbaru Niang is built using a knock-down construction method, where the building can be disassembled and reassembled without damaging the main materials, allowing them to be reused (Dwiputri, 2023). It is constructed with a tiered structure and distinctive joint systems. Its main structure is supported by nine pillars embedded directly into the ground, with a central pillar (*tiang bongkok*) connected to the uppermost part of the building through a pin-joint with another vertical member called *tiang ngando*.

While certain traditional houses, such as those in Duku Ulu Village, are highly vulnerable to earthquakes due to their elongated and asymmetrical forms, as well as structural systems that lack rigidity and rely on nailed joints with poor seismic performance (Triyadi et al., 2007), the Mbaru Niang in Waerebo presents a clear contrast. According to studies by Pradipto & Tristanto (2021) and (Dwiputri, 2023), Mbaru Niang demonstrates structural resilience through a well-integrated tectonic system that employs jointless construction methods such as tying, wedging, interlocking, and traditional wooden joinery. These techniques enable the structure to respond flexibly to wind and seismic loads while maintaining overall stability. The use of lashing joints, which preserve the integrity of the timber without drilling or cutting, provides greater resistance to shear, tension, and compression. This shows that vernacular architecture, when rooted in local knowledge and adapted through generations, can produce buildings that are not only culturally meaningful but also structurally durable in challenging environments (Fernandes et al., 2015; Idham, 2018).

Figure 8. Illustration of Knock-down Construction on Mbaru Niang (Source: Photo by Edward V. Gunawan (2025), used with permission)

By utilizing local materials and adapting to the climate, vernacular architecture offers cost-effective and culturally grounded design solutions that support healthy buildings and reinforce regional identity, particularly in tourism (Pinassang et al., 2021). It provides valuable examples of past design approaches that maximize limited resources through continuous adaptation and improvement (Fernandes et al., 2015). The roof of the Mbaru Niang, made from natural materials, requires special treatment to enhance its durability. One of the methods used is by smoking from the inside. The kitchen is placed inside the Mbaru Niang so that the smoke from the cooking process helps in the drying process (Juwono, 2017), which is necessary to make the roof drier and more durable (see **Figure 9**a). Materials combined with traditional construction methods and techniques are key parameters of sustainability, as they are renewable, recyclable, and provide user comfort (Durukan et al., 2021).

The foundation of the Mbaru Niang consists of several wooden beams planted into the ground to a depth of 2 meters. There was an issue with the foundation in the old structure, where the wood would rot due to moisture or become brittle, making it unable to support the entire structure of the house. With the arrival of guests and input from experts, the foundation of the Mbaru Niang is now wrapped in plastic and *ijuk* (Dwiputri, 2023) to protect the wood from direct contact with the soil and termites (see **Figure 9**b).

(a) (b)

Figure 9. (a) The kitchen is placed inside the Mbaru Niang; (b) Mbaru Niang Foundation
(Source: Roosandriantini, 2019)

High Contact

High contact refers to housing design that is deeply rooted in human values. It emphasizes individuals, not only as persons, but also encouraging a symbiotic relationship within families, communities, and the norms that influence elements of traditional architectural works and spaces. Two key aspects of the Mbaru Niang house exemplify this *High Contact* principle: the integration of natural and living elements around the house (Has a Biotope), and the role of communal spaces in sustaining social ties (Has Gathering Space).

Integration of Living Systems (Has a Biotope)

For the people of Wae Rebo, coffee is not merely a commodity or a means of warming from the cold mountain winds. Coffee has long been a gift and the breath of life for the people of Wae Rebo. In addition to coffee, there are also varieties of fruits (Pandjaitan & Ellisa, 2014). Additionally, the presence of animals such as chickens, pigs, goats (Je'e Mally et al., 2025), and dogs that is raised around the house reflects a way of life that is intertwined with the local ecosystem. Chickens are used in traditional offerings, symbolizing a spiritual connection to ancestral beliefs, while other animals contribute to the rhythm of communal life in the green open spaces of the village.

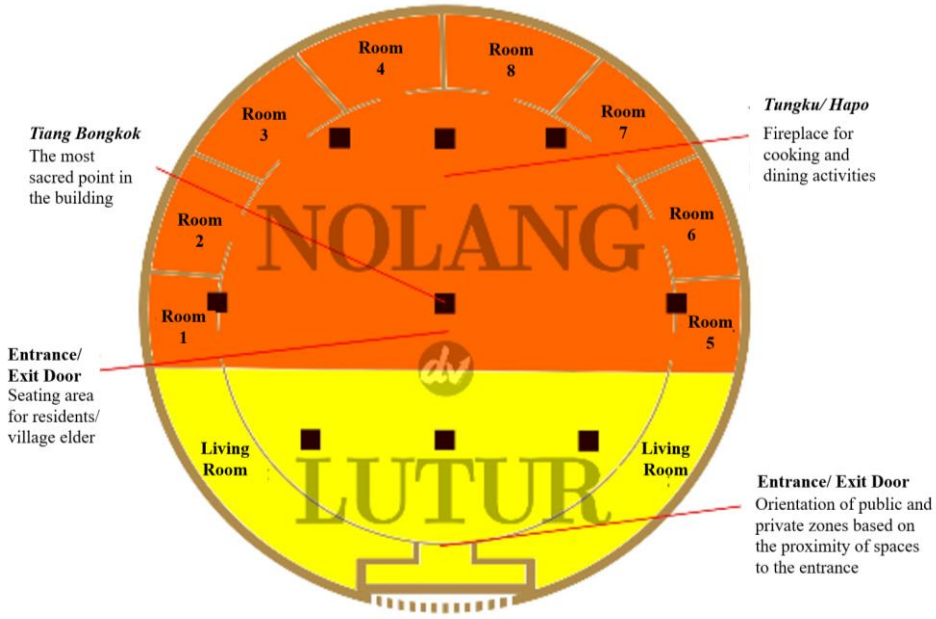
These elements illustrate how the architecture of Mbaru Niang facilitates a symbiotic relationship between humans, animals, plants, and spiritual practices. The house exists as part of a continuous interaction with its environment, embodying the *High Contact* objective of creating a built space that is responsive to and reflective of both ecological systems and cultural values.

Figure 10. Presence of Animals
(Source: (left) Photo by Edward V. Gunawan (2025), used with permission; (right) A. Sidiq et al., 2012)

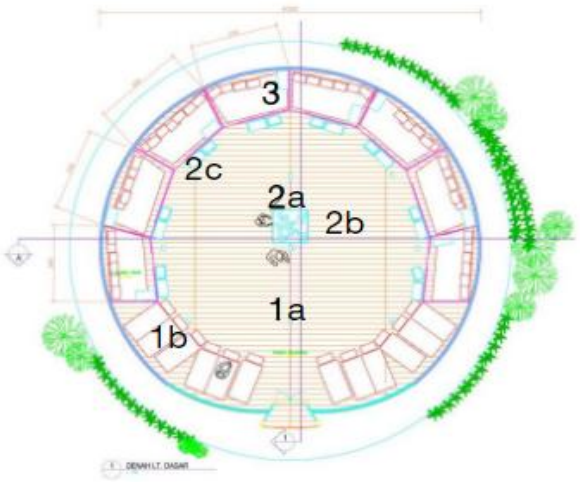
Sustaining Social Bonds (Has a Gathering Space)

Equally important is the role of the Mbaru Niang as a communal gathering space. The people of Wae Rebo uphold a unique philosophy. Initially, the elders of Wae Rebo had eight children, but the Niang houses were not built in eight to be inhabited by each clan. Instead, each Niang house, which has eight rooms, must be inhabited by descendants of each of these eight clans. The *Mbaru Tembong/Mbaru Gendang* is the center of the U-shaped formation. In this house, representatives (usually the elders) of the six households reside. This is where everyone gathers as a community to discuss village matters (see **Figure 2**, left). The spatial arrangement which facilitates shared living and interaction fosters a strong sense of kinship among the people of Wae Rebo, as their social bonds are strengthened through direct physical interaction within shared spaces (Louis, 2015). The Niang House functions as a spatial and cultural foundation, shaping communal roles and reflecting the structure of social relationships, while embodying the continuity of intergenerational ties within the community (Je'e Mally et al., 2025). According to Iwamura (2003), *High Contact* emphasizes a built environment that is not isolated from, but deeply intertwined with local human relationships, ecological realities, and cultural practices. In this case, the *Mbaru Gendang* serves as more than a shelter or meeting space, it is a spatial facilitator of kinship, governance, and continuity of tradition. The face-to-face interactions that take place within it are not incidental but essential to maintaining the social fabric and shared identity of the community (Salem & Tawfiq, 2023). The architectural form supports and amplifies this social dynamic, allowing space to become an active medium for nurturing intergenerational ties and cultural resilience.

The first floor (*Tenda*) is divided into two areas: *Lutur* (Public) and *Nolang* (Private) (see **Figure 11**). **Figure 11**b shows the zoning where 1A–1B represents the *Lutur* area, a semicircle towards the front for all public activities. 1A is the sitting area for house residents/elders, directly in front of the main pillar in each Mbaru Niang (*siri bongko*). 1B is the resting area for guests. 2A–2C represents the *Nolang* area, a semicircle towards the back, exclusively for the residents' activities, a more private area. 2A is the circulation area for private activities, 2B is the kitchen area, and 2C is the storage area with cabinets owned by each head of the family. 3 is the sleeping area, where each head of the family occupies one room with their feet always inside (facing the main pillar). The sense of togetherness among the people of Wae Rebo is also evident in the kitchen. In *Mbaru Tembong*, for example, there are 8 stoves for 8 families. This has been passed down through generations, and there has never been any conflict because, even though they cook together, each family still respects the privacy of others (Ampur et al., 2023). This spatial arrangement reflects more than just functional efficiency, it embodies a deep social logic. This occurs where communal living is harmoniously balanced with respect for individual privacy (Silva, 2025). The continuity of this practice across generations, without conflict, highlights how the built environment can support social harmony, mutual respect, and cultural resilience.



(a)



(b)

Figure 11. Private and Public Zoning
(Source: modified from Pinassang et al., 2021; Louis, 2015)

Figure 12. Mbaru Niang's Kitchen
(Source: Juwono, 2017)

Health and Amenity

Health & amenity refer to the community's approach to waste management and their culturally embedded understanding of comfort. This category consists not only physical health '*Be Safe'* but also psychological and cultural well-being '*Feel Safe'*, recognizing that comfort in architecture often reflects local traditions and environmental adaptation rather than advanced technology alone.

Be Safe (Physical Health)

In traditional settlements like Wae Rebo, the interaction between architecture and the natural environment extends beyond the interior of the house. Due to the small and limited openings in the building, the interior does not receive much light exposure. However, the light that does enter is sufficient to support activities inside Mbaru Niang, even though it tends to be dim. The sun is enjoyed outside the building, where its heat is used to dry harvested materials, and there is no shading from trees on the surrounding site. Daily interactions with natural light and warmth occur primarily in exterior spaces, where daylight is utilized efficiently. This interior condition reflects an adaptation to the local climate and cultural habits from maintaining the house from harsh environments (Motealleh et al., 2018). This spatial and environmental adaptation aligns with Iwamura's *Health & Amenity* principle, which emphasizes the creation of indoor and outdoor living environments that are not only physically healthy but also psychologically and culturally comfortable for residents. This is discussed in Fathy et al. (2009), suggesting that comfort in traditional architecture is culturally constructed rather than technologically determined.

(a) (b)

Figure 13. (a) Daily Interactions with Natural Light**;** (b) Light Exposure within the Building's Interior
(Source: Photo by Edward V. Gunawan (2025), used with permission)

In addition, the elevated setting and climatic conditions provide cool mountain breezes that are not only a natural feature of the environment but an integral part of the spatial experience. The temperature and air pressure from the lower part can enter through the gaps between the building's ground floor, which helps enhance thermal comfort inside the building during hot weather. The roof of the building serves as an air circulation system within the house, where cool air accumulates at the peak, preventing hot air from getting trapped and entering the building. Rather than relying on artificial cooling, *Mbaru Niang* achieves comfort through a spatial configuration that responds intelligently to its microclimate. The integration of breathable materials, strategic openings, and roof geometry creates a living environment that is not only physically healthy but also psychologically satisfying, as it aligns with local environmental knowledge and cultural expectations of comfort (Gulati et al., 2019).

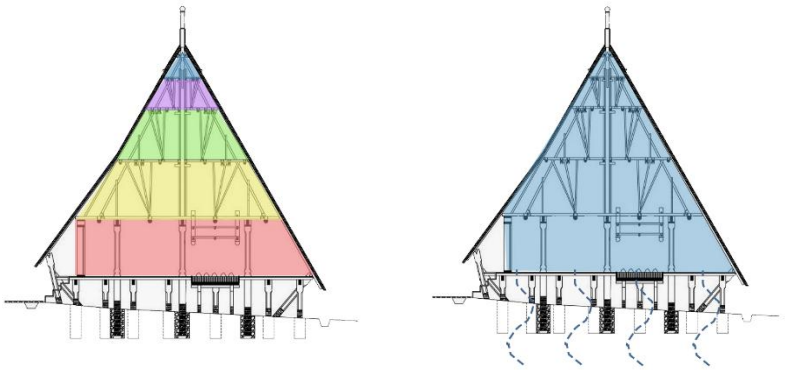


Figure 14. Illustration of Mbaru Niang Ventilation and Air Circulation
(Source: modified from Satwikasari, 2016)

Mbaru Niang is a raised house with a significant height, and the area beneath the building can be utilized as a communal space. For example, it serves as a place for mothers to weave *sarongs*, a playground for children, and a storage area. Additionally, the landscape area in front of the building is used as a multifunctional space for rituals, sports, and children's play. By allowing for social interaction, productive activity, and recreation within a familiar and climate-responsive setting, Mbaru Niang offers a flexible and inclusive environment that supports both communal cohesion and individual needs. The use of transitional spaces—such as the area beneath the house and the open yard—demonstrates how vernacular architecture fosters comfort not solely through enclosed interiors, but through a harmonious integration of indoor and outdoor functions (GhaffarianHoseini et al., 2014). This adaptability enhances quality of life in culturally meaningful and environmentally responsive ways.

(a) (b)

Figure 15. (a) Illustration of Communal Area in the Lower Area of the Building; (b) Multifunctional Landscape Area
(Source: Dwiputri, 2021; Pandjaitan & Ellisa, 2014; Juwono, 2017)

One Mbaru Niang is traditionally inhabited by six to eight families, accommodating approximately 30 to 40 individuals who all sleep on the same floor. As a result, the spatial arrangement offers little to no personal privacy for each family or individual. This condition is not viewed as a deficiency but rather reflects as a collective dwelling rooted in ritual practices and shared kinship (GhaffarianHoseini et al., 2014).

However, with Wae Rebo and its Mbaru Niang houses increasingly positioned as tourist destinations, the balance between cultural integrity and external exposure has shifted. Visitors now stay in these communal spaces and participate in traditional ceremonies (Sendjaja Suhandi et al., 2022), introducing unfamiliar dynamics that can challenge the emotional comfort and privacy of local residents. This evolving use of the domestic space reveals a tension between cultural sustainability and economic opportunity, underscoring the need to revisit the concept of health and amenity not only as physical or psychological conditions, but as culturally defined experiences that may be vulnerable to change under external pressures. However, the inhabitants of Wae Rebo have shown strong support for tourism development, as it is managed through community-based participation mechanisms led directly by the village chief (Nadriana, 2023).

Figure 16. Mbaru Niang's Privacy Aspects
(Source: Antar, 2013)

According to Lad (2013), the site is situated in a remote mountainous area at an elevation of 1,200 meters above sea level. Reaching Wae Rebo requires approximately five hours of hiking from the village of Denge along a steep and challenging path. This geographic isolation offers a sense of tranquility, privacy, and cultural continuity, which aligns with Iwamura's *Health & Amenity* principle—particularly in how residents derive psychological comfort from the clean air, quiet surroundings, and strong sense of place. However, such remoteness also presents significant limitations in terms of access to health services, infrastructure, and emergency support. As documented in several studies on isolated rural communities, these challenges can contribute to vulnerability, especially in relation to natural hazards (Kelly et al., 2011), resource scarcity, healthcare accessibility, and transport disadvantage (Delbosc & Currie, 2011). Thus, while the setting fosters a culturally embedded sense of well-being, it must also be understood within the broader context of uneven development and infrastructural exclusion, or even rural 'desertification'(Fraser et al., 2005).

Figure 17. Access to the site leading to Wae Rebo village
(Source: Google Earth, 2024; A. Sidiq et al., 2012)

Feel Safe (Comfort)

Due to the various activities carried out on the first floor of the Mbaru Niang, the design of the first floor is relatively flat and does not have much furniture. This is intended to allow the first floor to function as a communal

space, a sleeping area, a kitchen, a ritual area, and a place to receive guests. This multifunctional design contributes to both physical well-being and psychological comfort. By allowing the space to adapt to changing needs and group activities, the architecture supports a lifestyle that prioritizes togetherness, efficiency, and cultural continuity (GhaffarianHoseini et al., 2014). The absence of rigid partitions fosters inclusivity and shared experience, while the simplicity of the layout reduces clutter and enhances air circulation. This form of functional openness, rooted in vernacular knowledge, demonstrates how traditional architecture can provide comfort not only through environmental control but through spatial adaptability that aligns with cultural rhythms and communal life.

Figure 18. Mbaru Niang's Flexible Design
(Source: Pandjaitan & Ellisa, 2014)

Based on its geographical location, the Wae Rebo village is situated in an earthquake-prone area and surrounded by wild forests. Therefore, the buildings are elevated on stilts to ensure safety during disasters and to serve as protection from wild animals. Additionally, the conical shape of the structure is designed to withstand strong winds in the mountainous region (Pradipto & Tristanto, 2021).

Figure 19. Illustration of the Mbaru Niang Building Design that Maintains the Comfort of Its Residents
(Source: Urumkar,2017; Dwiputri, 2023; Pradipto, 2021)

The people of Wae Rebo replant trees in the forest that will be used for rebuilding their homes in the future. This wisdom has been passed down from their ancestors as part of the traditional architecture of the Indonesian archipelago. The materials used include *worok* wood, *alang-alang* (grass), bamboo leaves, lontar leaves, rattan, and *penti* wood planks (Lad, 2013). These materials support physical health by enabling effective ventilation, moisture control, and temperature regulation (Klaudia & Lapisa, 2019), all without the need for mechanical systems. Psychologically and culturally, they contribute to a sense of comfort and familiarity, as they reflect generations of traditional building knowledge and aesthetic identity. The use of non-toxic, biodegradable materials also minimizes health risks and aligns with broader principles of environmental sustainability (Valentini, 2023). Moreover, the tactile and olfactory qualities of these natural elements enhance sensory well-being, while the process of communal construction and maintenance strengthens social cohesion.

Several rivers surround the Wae Rebo village, with the Wae Lomba River being the closest and serving as a primary source within the local water system. Despite the availability of natural water resources, the community has not yet adopted a formal sanitation infrastructure. As a result, the design of *Mbaru Niang* houses does not incorporate built-in bathrooms or dishwashing sinks. Clean water for daily use is sourced directly from the river. However, a structured waste management system has yet to be implemented in the village, and specific details regarding waste disposal practices remain undocumented.

CONCLUSION

The study of Mbaru Niang, a traditional house of the Wae Rebo village, offers compelling insights into how traditional architecture can embody the principles of sustainable design as outlined in Iwamura's Environmentally Symbiotic Housing (ESH) framework. Through a detailed analysis, it can be seen that the Mbaru Niang house effectively integrates the three core pillars of sustainability: *Low Impact*, *High Contact*, and *Health & Amenity*. Under the *Low Impact* dimension, the use of locally sourced, biodegradable materials such as palm fibers (*ijuk*), bamboo,

and wood minimizes environmental degradation and reduces carbon emissions. The building's passive design strategies—natural lighting, ventilation, and thermal regulation—further contribute to energy efficiency without reliance on modern mechanical systems. Moreover, adaptive land use and knock-down construction methods enable both ecological sensitivity and material longevity, reflecting a deep alignment with sustainable resource management. The *High Contact* aspect is clearly visible in the Mbaru Niang's spatial configuration, which promotes social cohesion, communal rituals, and a symbiotic relationship with the natural environment. The architecture fosters collective identity and intergenerational continuity by integrating shared living spaces, gathering areas, and the cultivation of biotopes such as livestock and coffee. In terms of *Health & Amenity*, the Mbaru Niang provides a culturally embedded sense of comfort and safety. Its elevated design protects against environmental hazards, while the open interior allows for flexible, multifunctional use. Despite limited access to modern sanitation and healthcare, the structure supports physical well-being through effective air circulation, daylighting, and climate responsiveness. At the same time, the communal lifestyle and use of natural materials enhance psychological comfort and cultural integrity. After renovations by various parties (Yori Antar, organizations, etc.) in 1990, Wae Rebo has transformed into a tourist area that is not only suitable for its residents but also for tourists. The sustainability and health aspects of the inhabitants have significantly improved and become more evident.

While this research offers insights into the sustainability of the Mbaru Niang house through Iwamura's ESH framework, several limitations must be acknowledged. First, the research relies predominantly on secondary data sources such as literature, photographs, and architectural documentation, which may limit the depth of contextual understanding and the accuracy of site-specific conditions. The absence of primary fieldwork, interviews, or in-situ measurements restricts the ability to validate findings directly with local inhabitants or through physical performance testing. Second, the analysis focuses primarily on spatial configuration, overlooking other critical components of sustainable architecture such as construction lifecycle assessments, energy modeling, long-term material durability, and water and waste management systems. These limitations present opportunities for future research to explore the broader dimensions of sustainable architecture in the context of traditional houses.

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