

Construction System and Environment Adaptation of Traditional Architecture in Moluccas Island

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Abstract Traditional architecture has a variety of original and smart techniques to meet various needs according to the cultural context and natural conditions. Moluccas Islands is a natural disaster-prone area that has several unique traditional houses and was formed based on local wisdom, climatic, and topography conditions since the 13th century. This study aims to explore the traditional architecture in North Maluku Island by literature study and field observation to understand the design principles and building construction systems in response to extreme environmental conditions and to find out the sustainable features of traditional architecture in the past. Research focuses on five traditional houses located in different locations and topographical conditions by observing and analyzing site conditions, building orientation, construction techniques, building materials, ornaments, typology, and philosophy buildings. Study results show that sustainable features can be found on traditional houses in North Moluccas Island. Traditional houses of North Maluku were built using limited resources by passive design strategies and response to extreme conditions to achieve occupant comfort with the basic concept of "spiritual-human-nature". The characteristics of buildings differ in each region according to topographic conditions and local wisdom but in the same strategy: "harmony with nature" so that the traditional architecture of North Maluku can provide a comfortable living environment for occupants over the centuries according to the resources available at that time. The success of the traditional

architecture of North Maluku in adapting to extreme environmental conditions can inspire sustainable building designs in the future, especially for the archipelago context.

Keywords Traditional Architecture, Construction, Environment, Sustainability, Moluccas

1. Introduction

Indonesia is the largest archipelago country in the world, which consists of 34 provinces with 17,000 small and large islands. The total area is 5,193,250 km², more than 70% of the ocean with a coastline length of 81 km. Indonesia lies between latitudes 11°15'S and 6°08'N, and longitudes 94°45'E and 141°05'E. The population is around 270 million consisting of diverse cultures, religions, ethnicities, and local languages. Based on this condition, Indonesia has a variety of traditional architecture with different characteristics of each island, which is known as a "Rumah Adat" (custom home). Indonesia's traditional architecture is the most extraordinary vernacular building with different characteristics in each region and a unique carving ornament based on local wisdom character. They are strongly influenced by the natural environment and local culture [1].

The Moluccas Islands are located in eastern Indonesia

and consist of two regions, namely Maluku and North Maluku provinces. North Moluccas is predominantly an archipelago area of 1,474 islands and an area prone to natural disasters especially earthquakes and volcanic. North Maluku has several traditional architectures spread across several islands such as Falakanci house in Ternate and Sasadu in Halmahera. Traditional architecture is a characteristic and identity of an area so that it must be preserved and become a lesson for contemporary building design [2-3]. Cultural sustainability which influences people's satisfaction and identity of the country must be preserved and as government policy at the local and national levels [4], but along with the development of modern cities today some traditional architecture has become extinct. According to Wang [5] that traditional houses are severely damaged and threatened with extinction due to accelerated urbanization, weak awareness of citizens towards the preservation of traditional houses, lack of systematic study of traditional house construction methods, construction techniques, and spatial culture, and also new buildings are not in harmony with the character of traditional houses.

In addition, modern development raises various problems, where contemporary architecture loses its capacity to control the environment and tends to rely on technology that consumes a lot of energy, causing other problems that can damage the environment [6]. Technology cannot be the basic method for solving architectural problems related to the environment so that global concern leads to the concept of environmentally friendly architecture or sustainable architecture. Various study results before show that traditional architecture contains sustainability values that can be adopted in contemporary buildings [7-11], but on the other hand, traditional architecture is considered to have low or substandard quality [12,13]. Therefore, it is important to conduct further studies of traditional architecture to explore the positive features that are beneficial to sustainability. Learning from traditional architecture is very important and useful for building design inspiration in the future [14] and can lift the image of traditional architecture from the label of "low quality" [15].

According to Sundaraja [16] that the study of traditional architecture can provide insight and inspiration to contemporary building design by following design principles and local construction techniques from traditional buildings. Different climates require different architectural design strategies [4,17,18] so that the study of traditional architecture from various regions is needed for improving insight and inspiration to sustainability in the future. Therefore, this study will explore traditional architecture in the North Moluccas archipelago to understand the design principles and building construction systems in response to the extreme environmental conditions, and also analyze the positive features that can

inspire future sustainable building designs, especially for the context of the archipelago.

2. Literature Review

Sustainable architecture includes considerations of ecology, energy consumption, and occupant's health [19]. The successful application of ecological aspects in traditional settlements is an important lesson in realizing sustainable contemporary cities in the future [11]. Environmental and climatic conditions are important parameters in building design. The purpose of building design is to provide occupants comfort [20-21]. The attention paid to the natural environment ensures minimum negative effects and encourages the use of natural features [22]. According to Aram [23] that environmental factors, climate, religion of occupants, and people's lifestyles form the characteristics of traditional architecture. Climate has direct and indirect impacts on people's health and well-being, so that, the different climates require different architectural design strategies [17,24]. People who built traditional houses in the past did not have deep knowledge about the concept of sustainability at that time, but they worked based on experience and knowledge of climate and natural conditions around for the comfort of occupants [9,25].

A sustainable building can be defined as a building that considers the life of the building and quality of the environment, and the future value of its occupants [26]. Environmental sustainability is an important element in sustainability, so that, the building design must be in harmony with the environment. The concept of sustainable buildings describes the harmonious relationship between occupants and the environment. One of the sustainable systems in traditional houses is the application of passive techniques to achieve occupant comfort [20,27]. Kim [6] conducted a comparative study of traditional and contemporary architecture in responding to its environment and concluded that modern architecture cannot control its environment without using methods that involve high energy consumption, and it causes many environmental problems, but Korean traditional architecture has developed a system to control its environment effectively from old experience. Yaman [9] investigated the sustainability aspects of a traditional house in Ibrid Jordan; The design strategy of the traditional house at Ibrid is by optimizing natural ventilation and lighting systems to reduce energy consumption, and also utilization of a central courtyard in the building to circulate fresh air throughout the house. Rahim [28] investigated the performance of natural ventilation in the traditional building of Sultan's mosque in Ternate, found that the natural ventilation system can improve indoor thermal comfort to a comfortable level.

Preserving local architecture and passing it on to future generations is important in terms of sustainability. Knowing and appreciating the vernacular heritage is the first step to protecting it and demonstrating our commitment to future generations [29]. Traditional architecture can be developed as a tourist icon to improve the economy of the surrounding community and as a conservation effort. Putra [30] states that tangible and intangible culture can be developed as a cultural tourism object and local communities as the main actors because the community is the owner of tourism resources so that it can improve the local community's economy and also maintain its sustainability. Knowledge systems in the past as an important source of guidance for modern life [31]. Design principles, construction techniques, and sustainability values in traditional architecture can be used as guidelines for future design and construction [8]. The sustainability aspect of traditional architectural heritage will improve the process of creating sustainable buildings in the future without disappearance the place identity and remaining in the same cultural context [9]. For contemporary architecture to meet today's human needs adequately, vernacular values that apply to the cultural and climatic needs of the past must be absorbed [10]. On the other hand, research of traditional architecture in tropical islands is still very limited, especially in earthquake-prone areas. According to Soleymanpour [24] that different climates require different architectural design strategies. Therefore, this study focus to analyze the traditional architecture in the North Maluku Islands, where this region has several unique traditional houses since the 13th century and is a very vulnerable area of earthquakes and volcanoes.

The study of traditional architecture is very important to understand the culture and preserve it for the current generation [2]. Some previous research on traditional architecture in North Maluku, namely: Ibrahim [32] and Harisun [33] studied the typology and material of traditional architecture Falakanci. Rahim, M [34] investigated the typology of the traditional house of Folajikusesurabi and stated that the building characteristics use simple techniques with human anatomy philosophy. Nanuru [35] studied the Hibualamo culture: a cultural system that binds the people of North Halmahera as the basis of kinship and unifies the community. Wakim [36] analyzed the cultural aspects of the Sasadu traditional house and Hikmansyah [37] analyzed the form and function of the Sasadu house and they stated that Sasadu reflects to the cultural form of the local community. Sasadu houses are in harmony with local culture and include earthquake-resistant construction [38]. This study focuses to analyze the building construction systems in response to extreme environmental conditions as well as sustainable features applied to five traditional architectures in the past, which are spread over several

islands with different topographic conditions. The results of this study are expected to inspire future sustainable building designs, especially for the context of the archipelago.

3. Materials and Methods

This study is a qualitative research to explore traditional architecture in the North Moluccas archipelago to understand the principles of design and building construction systems in response to extreme environments, and also analyze sustainable features that were applied to traditional architecture in the past as an inspiration for contemporary architectural designs in the future, especially for archipelago context. The study area is located in eastern Indonesia on Moluccas Island (see Figure 1). The traditional houses in Moluccas Island are scattered in several islands and districts. Therefore, the object of study is focused on five traditional houses in the north Moluccas region, which are spread over several islands with different topographic and geological conditions, namely: traditional houses of Falakanci and Falagaku in Ternate Island, Folajikusesurabi (Folajiku) in Tidore Island, Sasadu in West Halmahera and Hibualamo in North Halmahera Island (see Figure 2).

The research was performed by literature study, field observations, and interviews as conducted by several previous researchers [11,14, 29] to find out positive values on building construction systems, environmental adaptation strategies, and sustainable features using descriptive and architectural analysis to the conditions site, building orientation, construction techniques, building materials, ornaments, typology, and building philosophy. Sustainable features are analyzed using building sustainability assessment methods (see Figure 3).



Figure 1. Study area in North Moluccas Island

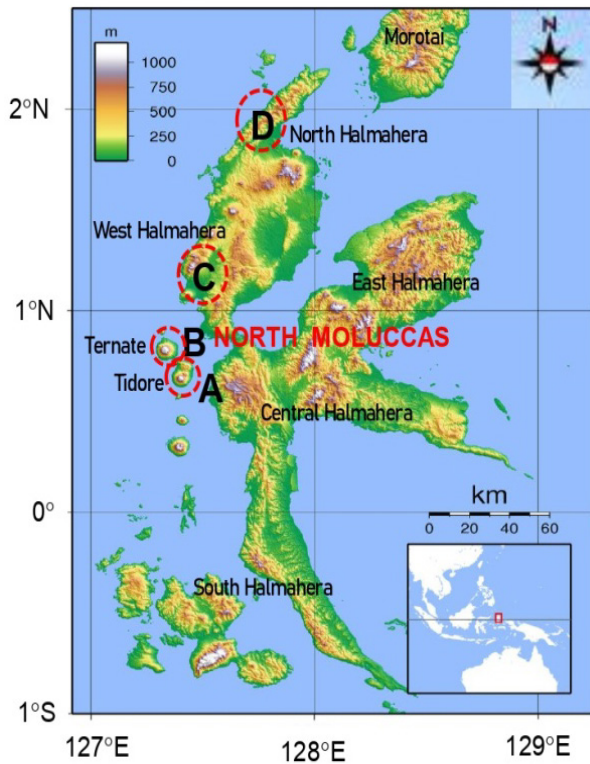


Figure 2. Study objects (A: Folajikusesorubi, B: Falakanci & Falagaku, C: Sasadu, D: Hibualamo)



Figure 3. Core categories in Building sustainability assessment methods [39,40]

4. Results and Discussion

4.1. Environment Condition

The Moluccas Islands are located in eastern Indonesia. The geographical position is in the equator with a temperature range of about 23-33°C (tropical climate). At first, the Moluccas Islands were a single province and split into two provinces on October 12, 1999: Maluku and North Maluku (North Moluccas). North Moluccas have been recognized by the world since the period of the Sultanate "Moloku Kie Raha" (Four greater sultanates in North Maluku) in the 13th century. North Moluccas has a very diverse population of around 28 ethnics. The total area of North Maluku Province reaches 31,982 km², where the area is a dominant ocean of about 75%. North Moluccas consists of 1.474 islands with the number of islands inhabited is 89 and 1.385 uninhabited. It consists of 10 regencies with a population is 1.255.771 people in 2019.

Table 1. Environment Characteristics

Vernacular	Topography	Climatic	Disaster
Ternate (Falakanci Falagaku)	Mountain (Volcano)	Tropical Mountain & Marine Climate	Volcano & Earthquake
Tidore (Folajiku)	Mountain	Tropical Mountain & Marine Climate	Volcano & Earthquake
Sahu (Sasadu)	Mountain (±60%)	Tropical Marine Climate	volcano, Earthquake, flood
Tobelo (Hibualamo)	Mountain (±40%)	Tropical Marine Climate	Earthquake, flood

The Moluccas Islands comprise some of the most geologically complex and active regions in the world, where NorthMoluccas is a very vulnerable area from volcanos and earthquakes (see Figures 4 and 5). Since the 16th century, Gamalama Volcano in Ternate has erupted more than 400 times on various scales [41]. The biggest eruption occurred in 1775 causing the formation of two craters and then forming a lake at the foot of the Gamalama volcano. During 1600-1999, 105 times tsunami has occurred in Indonesia 50% in around Mollucas Island (Banda sea and Moluccas sea), 32 times tsunami occurred in Moluccas (4 by a volcanic eruption) [42].

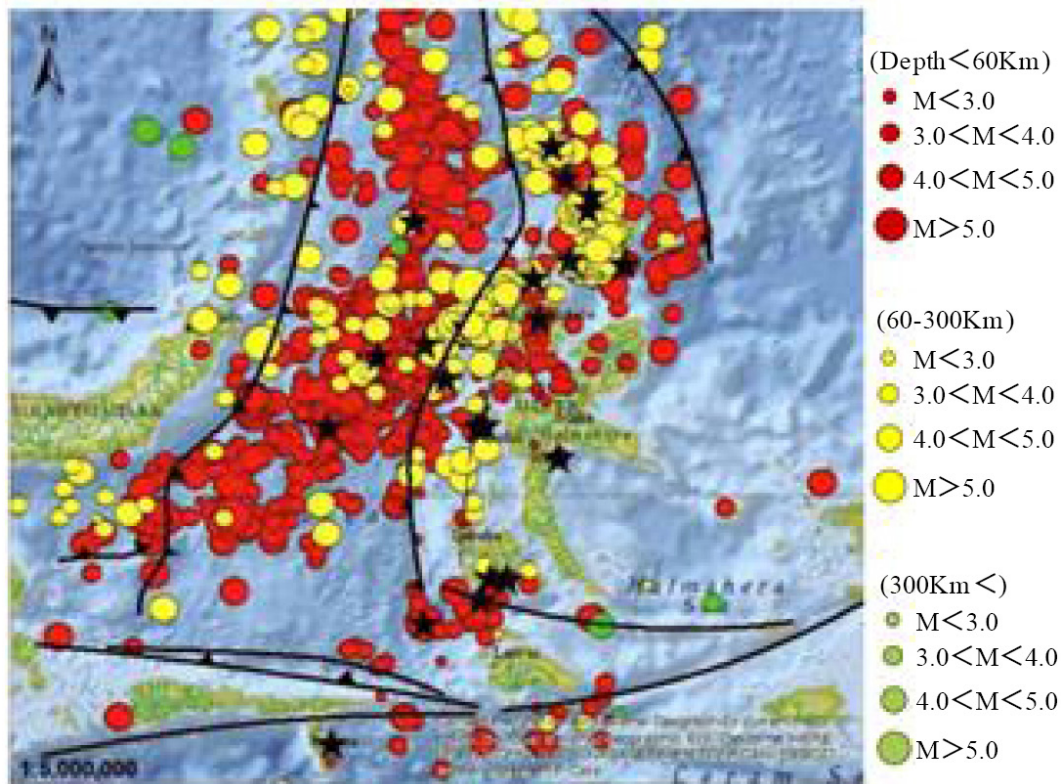


Figure 4. Spatial distribution of Earthquake in North Moluccas in 2018

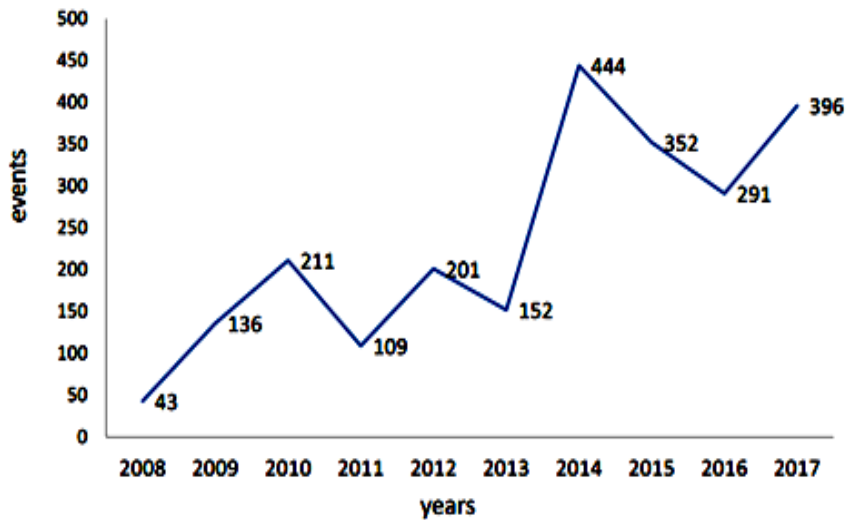


Figure 5. Earthquake Intensity in West Halmahera, North Moluccas

(Source: Author)

Table 2 shows the latest earthquake events for 2019-2021 in the North Maluku region. It shows that the northern Maluku region is often hit by large earthquakes around 7.0 mag. and caused property damage and death. In 2019 there were 3 times earthquakes above 7.0 Mag, and one of them caused severe damages to more than 2800 buildings with light and heavy damage and 13

people died [see Figure 6]. This earthquake is a mainland earthquake centered in Halsel (South Halmahera). In 1998 the earthquake of 7.7 mag in Taliabu, North Maluku caused a tsunami of about 3 m and 34 deaths. It shows that the northern Maluku region is very prone to earthquakes so that people must protect themselves and train mentally in dealing with these extreme disasters.

Table 2. Earthquakes over 5 Mag. in North Mollucas

Date	Location	M	Depth km	Epi center	Damage	
					Build.	Death
2019						
5-Jan	Halsel	5.1	10	sea		
7-Jan	Halut	6.5	47	sea		
16-Jan	Morotai	5.3	10	sea		
16-Mar	Halsel	5.6	49	sea		
7-Jul	Ternate	7.1	49	sea		
14-Jul	Halsel	7.2	10	land	> 2862	13
24-Mar	Halbar	6.3	10	sea		
14-Sep	Halsel	6.2	41	sea		
14-Nov	Ternate	7.1	73	sea	> 36	
14 Des	Halsel	5.3	23	sea		
2020						
6-Apr	Halbar	6.1	67	sea		
13-Apr	Ternate	5.1	13	sea		
15-Apr	Ternate	5.9	13	sea		
4-Jun	Morotai	6.8	111	sea	> 100	
15-Jun	Halut	5.7	97	sea		
12-Aug	Halbar	5.3	10	sea		
6-Sep	Halbar	5.9	10	sea		
25-Nov	Halbar	5.1	71	sea		
2021						
26-Feb	Halsel	5.1	10	land	> 447	
20-Mar	Ternate	5.3	37	sea		

Halbar: West Halmahera, Halut: North Halmahera, Halsel: South Halmahera



Figure 6. Building damage due to earthquake in Halsel, 2019



Figure 7. Falakanci house that survived the 7.7 mag earthquake in Halsel, 2019

The people of North Maluku are aware that the dangers of natural disasters can threaten their lives at any time, especially earthquakes, but because of all the limited

resources and finances, the people are unable to build houses that meet earthquake-resistant technology, so that they try to protect and train themselves with simple techniques, namely: (1) Mental training from childhood in dealing with extreme conditions. (2). Build houses that are believed to be resistant to extreme conditions: with all the limited resources, the community protects themselves based on local techniques by building a simple houses using natural materials and reinforced with a button system such as the Sasadu and Falakanci house. People believe that the houses of Falakanci and Sasadu are strong to withstand shocks [32,33,38]. Several Falakanci houses survived total destruction the 7.7 mag earthquake at South Halmahera in 2019 (see Figure 7). (3) Disaster escape system: escape to mountainous areas during an earthquake and escape to coastal areas when a volcano erupts.

The people of North Maluku are trained to live hard work and help each other since childhood in dealing with extreme conditions, and they are trained in gardening, fishing, and hunting to meet their daily needs, especially in emergency conditions, even the main sources of life for traditional people in the past were fishing and gardening. In mentally training for dealing with extreme disasters, they are trained since childhood by instilling the understanding that "disasters will come when God is wrathful due to humans do evil and destroy nature, so they must always pray for self-protection and live in harmony with nature to avoid disasters". Self-rescue strategies during disasters are taught since childhood that when an earthquake occurs, they must save themselves to

mountainous areas because there are gardens that are the source of life, where the gardens are generally planted with tubers, coconuts, bananas, and various other plants that can fulfill the necessities of life for the few days before the disaster response team arrives, in these gardens, there are also garden houses available for shelter and also as a logistics warehouse, and in mountainous areas; there are springs and freshwater rivers as alternative sources of clean water in an emergency. When a volcanic disaster occurs, they must save themselves to the coastal area because there is a source of life from the sea and to facilitate evacuation to other islands. It shows that the people of northern Maluku were trained to deal with extreme disasters from a long time ago with the local techniques according to their comprehension and conditions at that time. Although this is just a simple strategy, this preparedness can reduce disaster risk.

4.2. Construction of Traditional Houses

Figure 8 shows the Sasadu traditional house in West Halmahera Regency in Jailolo and Sahu Districts. Initially, the traditional settlement of the Sahu tribe formed a customary group in a kinship. In ancient times, the traditional villages were generally located in the mountains. This indicates that the Sahu community has a harmonious life with their environment. Before the existence of the Sasadu, the traditional houses in the forest

were made in the form of simple houses (Koseba) with wooden poles embedded into the ground. These houses form a village or village settlement. These settlements move around from place to place because of security factors and economic resources; they move to potential areas for farming, hunting, and collecting rattan, resin, etc. It confirms previous studies [43-47] that economic factors will influence the development and characteristics of traditional architecture.

In 1910, a group of people settled in a location that is now Lolory Village. Initially, this group lived together in a large main house (Sasadu house), but due to marriage and family numbers become more and more so that they built houses around the main house. It becomes a small village and then developed into a village known as Lolory Village [37]. Furthermore, Sasadu functions as a room gathering, deliberation, traditional activity for the community in Lolory Village and surrounding villages. Sahu settlements are generally stretching along the main road of the village and the Sasadu traditional house in the center point. Indicating that the settlement is formed from the strong value of custom so that the settlement patterns are oriented to the Sasadu traditional house and displaying identity as a sultanate community. This confirms the previous study that traditional houses are originated from culture and become the character of a region according to the history and lifestyle of its people [2,3,48,49].

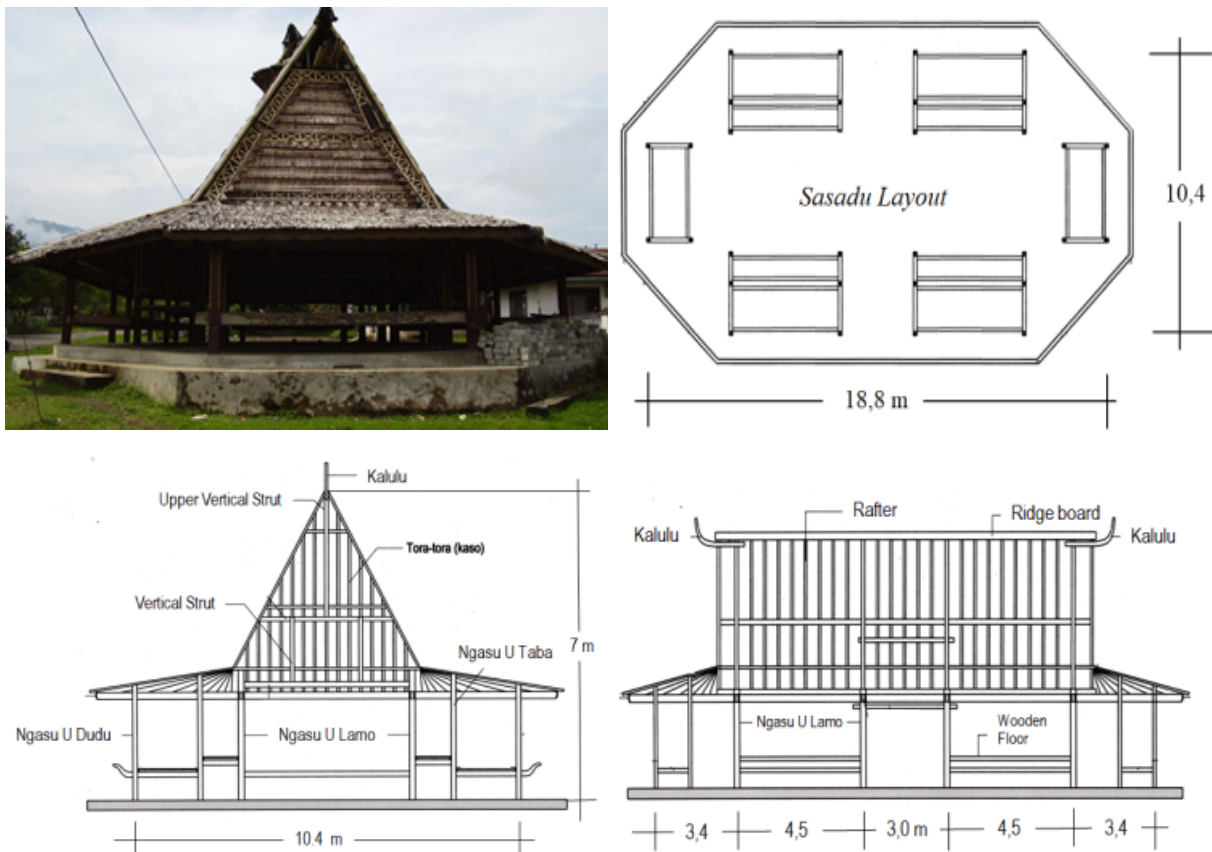


Figure 8. Traditional House of Sasadu in West Halmahera

At first, the Sasadu house functioned as a residential house for several families. In the next development, the family who lived in the house built other residential in the surrounding area. At present, Sasadu functions as a place for deliberations and special ceremonies for the village community. The layout of the Sasadu house is an octagonal shape, which is divided into two parts: the side space surrounding the central space is octagonal with a stone base consisting of 12 outer pillars (*Ngasu U Dudu*) and 12 central pillars (*Ngasu U Taba*). The center room is rectangular with the base of 8 main pillars on the rock (*Ngasu U Lamo*). Building material uses the local material of wood for a pillar and roof truss, bamboo and palm leaves for the roof, stone for foundation and pillar holder. The shape of the upper part of the Sasadu consists of a low-sloping roof arrangement surrounding a taper-shaped high triangular roof and there is a boat ornament (*Kalulu*) at both ends of the roof. It portrays that Sasadu architecture is the architecture of the boat community (maritime). This maritime symbol becomes the identity of the region and emphasizes that people's activities and life sources depend on marine resources. Art and architecture are the main identities of each country, the culture of each community determines community identity and architecture as social phenomena originated from the culture [50].

Figure 9 shows the traditional Houses in Ternate. The people of Ternate have two types of residential houses, namely the Falagaku and the Falakanci. Initially, the Falagaku house consisted of two types, namely houses for a native tribe of Ternate and houses for the Buton tribe in the Sabia and Koloncucu villages, Ternate City. The house for the native tribe is generally called garden houses because they are built-in kailyard as a shelter or rest, and also called Sabuah (local language) [32]. The model of Falagaku house is the house on stilts because of safety reasons to avoid the disturbance of wild animals.



Figure 9. Traditional houses in Ternate, (a): *Falakanci*, (b): *Falagaku*

At first, the traditional house of Falakanci uses a button system without the usage of nails or materials made of iron. It's only using straight hooked lip joints and a peg which are also made from wood or bamboo and gamutu ropes (palm fiber rope) all of which function as reinforcing joints. The size of the room does not have a specific standard, which may differ depending on the

wishes of the occupants, but in general, a rectangular floor plan with the main building separate from the kitchen and there are four pillars on the porch, using natural materials namely bamboo, wood, the roof of thatched leaves with the ties of gamutu rope. The roof model is a pyramid-shaped roof with a high king pillar. The house room consists of a terrace, living room, bedroom, and family/dining room, while the kitchen is separate from the main building. According to Marasabessy [51] the falakanci house is responsive to earthquake loads because it uses a wooden frame construction with a reinforced button system.



Figure 10. Traditional House of *Folajiku* in Tidore

Figure 10 shows the traditional house of Folajiku in Gurabunga Village in Tidore Regency, which consist of 5 traditional houses, namely Fola Sowohi; house for a leader of a custom, Fola Tosofu: house for a leader of Sufism, Fola Toduhu: house for the leader of a sea area, Fola Mahifa: house for a leader of philosophizing, Fola Tosofu Makene: house for a leader of jurisprudence [34,52]. Gurabunga community uses the proportionality of human anatomy for the dimension size of the material: foot, hand lengths, and fathoms. The building layout is a rectangular model with the room's core space consisting of Sarabi (terrace), Konora (reception room), Fuji (traditional ceremony room), Jiko/madola (bedroom). The typology of buildings is rectangular consisting of the main building and the kitchen being built together. Folajiku traditional house is symbolized by the anatomy of the human body: the roof symbolizes the human head. The house pillar symbolizes the *Kapita* (bodyguard) of the five clans or the five traditional houses. The window symbolizes openness and generosity, the door symbolizes the long clothes (robes), which are commonly worn by the Sultans, a wall symbolizes the human body. The king pillar symbolizes the strict nature of the leader, and the foundation symbolizes human feet. It portrays that the values of local wisdom are very strong in the traditional architecture of folajiku with a spiritual-human-nature harmony approach. They believe that living in harmony with nature will bring peace and comfort for the next generation.

Figure 11 shows the traditional architecture of Hibualamo in North Halmahera. This local wisdom is rooted in understanding that the entire population in the North Halmahera region is of one descent and occupies one big House as a place where they live in harmony, solving common problems and tolerance. The first

Hibualamo building was established in 600 AD, but it is several times suffered destruction due to war, then it rebuilt after the independence of Indonesia around 1945-1950 [35]. Hibualamo building is a rectangular form and consists of 4 entrances: north, west, east, and south orientations. It symbolizes openness and unity without being distinguished by ethnicity, religion, and filiation. The dominant color in the traditional Hibualamo house is 4 colors; black: solidarity, red: fighting spirit, yellow: intelligence, grandeur, and wealth, and white: the sanctity of society. Hibualamo is a large house that is inhabited by a large family of Hibualamo residents who is gathered in 10 tribes and spread throughout the mainland of Halmahera, Morotai Island, and Loloda. The function of Hibualamo is as a center of kinship for residents to discuss common interests and needs, discuss the problem solutions, formulate policies and regulations concerning life and organize of community, traditional ceremonies, meetings rooms, and also for customary activities: celebration the ceremony of planting and harvest, marriage ceremony, room for the reception of guests and decide of customary sanctions. The cultural nuance and living together are an icon of this traditional house and can be an inspiration for the current generation that "togetherness" is one of the most important factors in realizing a comfortable community life. It also contains insight that realizing development that is responsive to local wisdom and sustainability must be carried out together in every generation. This is an important lesson that must be transferred to current and future generations. Local wisdom must be preserved for the next generation to improve the process of creating sustainable buildings in the future without disappearance the identity of the place and remaining in the same cultural context [9]. Positive values on traditional architecture in the past is important guidance in modern life [2,29,31].



Figure 11. Hibualamo in North Halmahera

The cultural influence is very strong on traditional architecture in North Maluku, because various tribes produce architectural works in various forms of traditional houses. Based on hundreds of years of experience, the community has produced traditional residential developments that are adapted to the local climate and geomorphology to accommodate the daily needs of its inhabitants so that this traditional architecture has many positive values that can be transferred to contemporary architects and engineers in terms of environmentally responsive design. Traditional methods can be adopted for contemporary buildings such as building elements,

characteristics, styles and expressions. Elements of sustainable design are integral to the vernacular architecture of North Maluku, which has evolved using local materials and technology according to characteristics of the natural and cultural environments creating harmonious relationships of community with the environment. In architecture design, Sustainability is an essential part of determining the regionalism architectural identity [53-54]. Identity has a permanent nature, which is supported by the natural environment and culture including views and habits [55].

4.3. Philosophy and Environmental Adaptation

The philosophy of a building foundation is likened as a human foot. The foundation of a traditional house in North Moluccas consisted of a foundation from the stone pile (sengkedan). The usage of the sengkedan foundation is influenced by the availability of local material and the topography condition of the building site, where the site of the building is contoured and sloping. North Moluccas consists of clusters of islands and mountains so that most dwellings spread in the mountains, valleys, and coastal side. In mountainous areas, the building foundation uses stone piles and wood materials. Wood heightened on a rock creates a high floor to form a stilt house. Generally, the foundation is made like that because it adjusts to the condition of the sloping ground contour and protection against the threat of wild animals. However, some buildings in mountainous areas are not raised above ground level because the site conditions are more stable and flat, such as the traditional house of Folajikusesurabi in Tidore, and also in the valley and coastal areas the building floor is not elevated and the foundation also uses a non-adhesive stone structure. It shows that the adaptation of the building is adjusted to topographic conditions with considerations of safety and comfort. According to Philokyprou [3] that topographic conditions: coastal, lowland and mountainous areas affect the adaptation of buildings so that different environmental conditions required different architectural design strategies [24].

The philosophy of a building body is likened to a human body. The body concept of a traditional house is the building's wall. The building wall consisted of the building body structure, filler material/wall, and decorative ornament. The building body structure at the traditional house of North Moluccas is the frame structure system or skeleton, which is reinforced by a peg or bound. At Falakanci house in Ternate, the wall structure system is a stiff frame structure, which is strengthened with a peg. The room composition consists of a reception room, bedroom, storage room for heirlooms or customs, and the kitchen is separate from the main building. In Falakanci's house, the bedroom is located on the left of the building, it is as a philosophy of the human heart on the left. The number of building pillar has a meaning in the social status

of its inhabitants, as found in traditional houses in Ternate. The house has 8 pillars on the front porch indicating the occupants are the Sultan's family, the 6 pillars are the Jogubu or prime minister and commander, while the 4 pillars are the Fanyira house (chief of a clan, custom, and district). It shows that tangible and intangible cultural values are very strong in the philosophy of traditional architecture in north Maluku. Putra (2021) [30] stated that tangible and intangible cultures can be developed as cultural tourism objects in an effort to preserve and improve the economy of the local community.

Wall material uses local materials such as wood, bamboo, and fronds of the sago tree. The usage of natural materials from the surrounding area indicates a harmonious relationship with the surrounding nature and they are able to withstand earthquake shocks. The material dimension uses the analogy of the human body such as feet, hand span, and fathoms. The height of the building uses proportions of the human body and generally following the proportion of women's height. Building ornaments are found in traditional buildings with the motif of carved animals (turtles, snakes, and fish), flowers, and leaves. The usage of natural materials is based on economic consideration, environmentally friendly, and available in the surrounding areas. Stone piles are used as a building foundation because it has a good function in dampening vibrations and is easy to arrange according to contour condition. It confirms the study before [56] that environmental and Geographical characteristics are the most important factors in the design and construction of traditional architecture.

The philosophy of roof building: a roof is likened to a human's head. The roof model in the traditional house of North Moluccas is diverse and varies in each area. Sasadu roof is a materialization of body Kagunga (sultanate boat), in someplace also referred to as Sabua (local language), cover or roof of the Sultan boat. Philosophic meaning from the roof is very strong because it's supposed as a human's head, as the most respected/esteemed part. The roof of a noble's house in Ternate has a higher size compared to the roof of ordinary people's houses. The roof structure is generally constructed from wood, there is also using bamboo, with the integrated roof structure system with the wall structure system. In traditional houses in Ternate and Tidore, there is the main pillar supporting the roof (the easel depress log), so-called the king pillar. King pillars have meaning for each region. In

Ternate's traditional house (ordinary people's house); three king pillars symbolize a harmonious occupant's relationship with God and both parents, which contains spiritual meaning that the occupant is obliged to increase worship to God, maintain good relations and harmony with parents. The length of the king pillar varies by around 25% building-width dimension. Roof material uses sago leaves and palm fiber. Sago leaves are arranged and bent simply on a dried bamboo sheet so that it forms a rectangle, resembles the shape of a comb, making in an impression of a natural, beautiful, and repetition of patterns. The length of the sago roof is around one of the human hand spans.

The traditional architecture of North Maluku can adapt to the extreme environmental conditions using local techniques and natural material from the surrounding area namely bamboo, wood, roof of thatched leaves tied by gamutu rope, wall material from sago stem (Fig. 12d). Building construction using wood frame construction with the reinforcement of a bond system of gamutu (palm fiber) ropers (Fig 12b) and button system using straight hooked lip joints and peg of wood/bamboo (Fig 12a). The roof model is a pyramid-shaped roof with a high *tiang raja* (king pillar) (Fig. 12c). The building site is located in an area of potential living resources and maintains natural conditions for the preservation of a comfortable microclimate. Adaptation to extreme climates uses a passive strategy through natural lighting, cross-ventilation, and usage of natural materials and vegetation for sun protection. This strategy contributes to reducing energy consumption in buildings, furthermore, it is useful for reducing greenhouse gas emissions, where the majority of greenhouse gases are produced from the process of burning fossil energy [57], so that, this strategy can be an inspiration for sustainable contemporary building designs. According to Rahim (2020) [8] that the passive solar design strategy is to integrate building elements with natural environmental resources without mechanical devices and energy supply, which consists of three categories: passive solar heating systems, passive cooling systems, natural lighting systems [58]. It confirms that traditional architecture is not low or substandard quality as stated by several previous researchers [12,13], but this strengthens the study results from various regions of the world [7-11,43] that traditional architecture contains sustainability values that are beneficial to contemporary buildings today and in the future.



Figure 12. Building construction: (a) Button System (b) Bond system, (c) Tiang raja (king pillar), (d) gaba-gaba (sago stem), (Source: author)

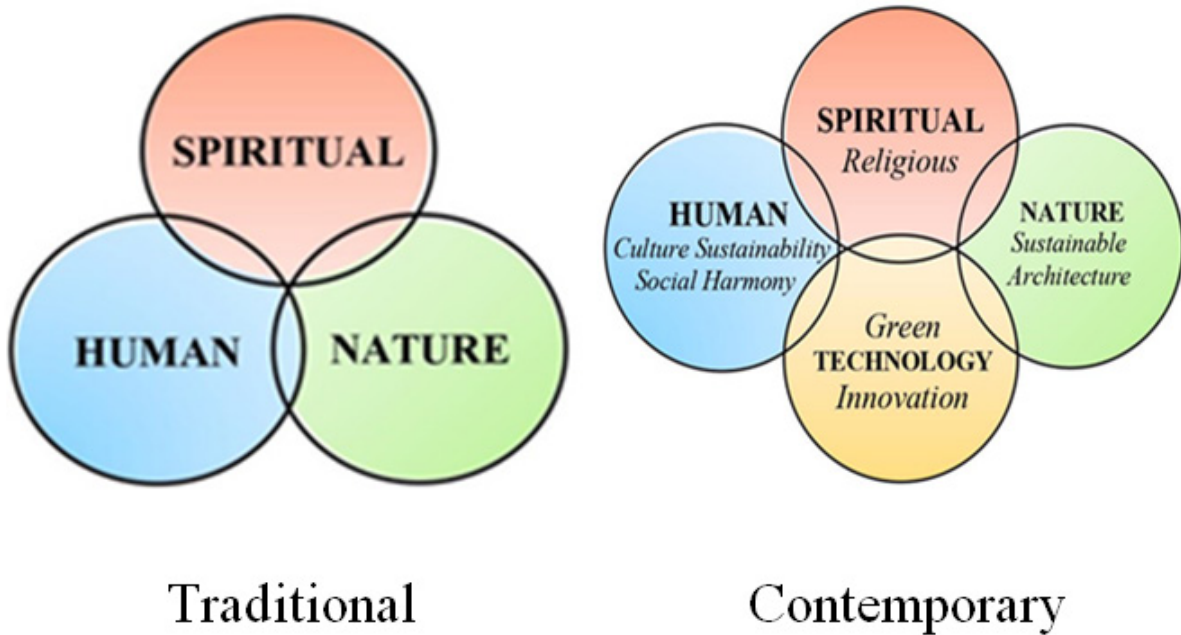


Figure 13. The basic building concept in North Mollucas Island. (Source: Author)

4.4. Sustainability

Sustainable buildings consider the "life-building" and environmental quality, and the future value of occupants [26]. The concept of sustainable development was described by the 1987 Bruntland Commission Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs [59]. Economic, environmental, social, and cultural sustainability are the pillars of sustainable development [45,47]. The traditional architecture of North Maluku contains sustainable architectural features where the basic concept combines aspects of spiritual (divine), human (dwelling/social), nature (economic/source of life) (see Figure 13). The construction of a house is always preceded by a ritual or prayer to God as a symbol of an application for permission to build a house and supplication for sustenance and health for its inhabitants. Spiritual values are very strong during the construction process and building philosophies such as the philosophy of the king pillar as a symbol of a vertical relationship with the Almighty [8]. This shows that religious factors are influential in the traditional architecture of North Maluku, this is in line with what was stated by [23] that environmental factors, climate, environment, occupant religion, and people's lifestyles form the characteristics of traditional architecture.

The community builds harmonious relationships among human beings, especially in one community so that the process of building houses is carried out in mutual cooperation led by the customary leader/builder. The human aspect is also manifested in the philosophy of the building, where buildings symbolize a human in a standing position (see Figure 13); where the building

foundations symbolize human feet, walls and rooms symbolize the human body, and the roof symbolizes the human head and also use of human anatomy as a measure of building dimensions such as fathoms, span, and foot. In the daily life of the people of North Maluku; Their life source depends on natural resources so that they build a life in harmony with nature with the philosophy of "when humans take care of nature, nature gives life to humans, when humans destroy nature it will bring disaster to humans". These are positive values that can inspire modern society in realizing a sustainable system in the future. The positive values of the past are an important guide for modern life [30,31].

Strategies of vernacular architecture can be used for the design of modern buildings and urban areas [40]. Traditional architecture is the content of sustainable architecture [60,61]. The characteristics of traditional North Maluku architecture that are friendly to nature and response to natural disasters can be adopted into contemporary building design by integrating green building design approaches to meet the needs and expectations of today's society to contribute to the creation of a more sustainable. Sustainable architecture considers the aspect of ecology, energy consumption, and healthy of occupants [19]. The ecological concept in the traditional architecture of North Maluku is manifested in the use of natural materials from the surrounding areas and the application of vegetation as a heat filter from the sun. The use of local materials can reduce transportation costs and fossil energy consumption. Considerations of energy consumption in the past have not been a concern because they use traditional lighting, but the application of passive systems and natural materials is beneficial in

reducing energy consumption in buildings.

Adaptation of buildings to climatic conditions and protection of buildings from the dangers of natural disasters is an effort to realize the comfort and health of building occupants. The health of building occupants is of particular concern with the philosophy of “the house is in one heart with occupants”. Realizing a house is in one heart with residents through two dimensions: tangible and intangible. The spiritual dimension (intangible) is a harmonious vertical relationship, performing various traditions and rituals, such as praying for starting construction process of a house, praying to construct a *Tiang Raja* (king pillar), praying to enter the house, all of which is done so that the occupants are of one heart with the house; avoid the disturbance of supernatural beings, avoid natural disasters, live in harmony, given the blessing of fortune and long life. Tangible dimensions through building construction techniques; the application of construction of buttons and bond systems for protection to the extreme disasters and adaptation to local climatic conditions through the application of a passive system. The passive system is one of the sustainable strategies for improving occupant comfort [27,62-67] and the purpose of building design is to provide occupants comfort [20-21].

The design principles, construction techniques, and sustainability values of traditional architecture can be used as guidelines for future design and construction [9]. The use of natural materials and passive systems in traditional houses of North Maluku can inspire contemporary building designs. Sustainable features in traditional northern Maluku architecture can be observed and transferred into the future; the principles of adaptive design with microclimatic conditions and disaster protection with local techniques: buttons and bond systems can be used as a guide in realizing sustainable

buildings in the future. This confirms the results of previous studies that traditional architecture contains sustainable and beneficial features for contemporary architecture [7-11]. Values of traditional architecture is higher than contemporary architecture in environmental perception [68]. In addition, the building adaptation differs in each region according to the climatic and topography conditions; the architecture of *falakanci* and *folajiku* is oriented towards mountainous areas where they are located in the majority of mountainous areas, while *Sasadu* and *Hibualamo* combine sea and land philosophies according to the conditions of their location and people's lives. It shows that the life pattern and culture affect the characteristics of traditional houses.

The traditional architecture of North Maluku is influenced by several factors, such as aspects of climate, environment, culture, and religion. The people of North Maluku build their houses according to the possibilities, needs, available materials, topography, culture, and religion without architects and uncontrol from government or regulations, but they construct based on climatic considerations from long experience in past with passive design strategies and utilization of natural materials from surrounding areas for improving indoor thermal comfort. This strategy is relevant to be considered for the design of energy-efficient buildings in the future. Traditional buildings use local techniques but can create occupant comfort [6,8,10,32]. Currently, architects and designers are generally less consider sustainable design principles in design building including in North Maluku, so that, sustainable design principles from traditional architecture [Table 3] are expected to be an inspiration for contemporary building designs in North Maluku and other areas that have similar environmental conditions, especially archipelago context.

Table 3. Sustainable features from traditional architecture (Recommendation for contemporary building)

Sustainability	In past (Traditional)	Future (Contemporary)	Application
Awareness & Education	<ul style="list-style-type: none"> Based on experience and local wisdom Spiritual & Culture Social Life: Share Work 	<ul style="list-style-type: none"> Respond to a sustainable culture. The design of the building must respect the religion and culture of the occupants. Involving all parties in providing input/decision on building design concepts including owners and prospective occupants. Building forms conform to the character of the surrounding environment and un show excessive social status. 	Sustainable Architecture Design
Energy & atmosphere	<ul style="list-style-type: none"> Natural ventilation & lighting Utilization of rainwater, river water, and wells. 	<ul style="list-style-type: none"> Building energy saving. Minimize fossil energy consumption for reducing CO₂ emissions in the atmosphere. Development of clean energy such as solar energy. Application of passive solar house to reduce the use of air conditioning Utilization of rainwater as an alternative source of clean water 	
Material & resources	<ul style="list-style-type: none"> Natural material from the surrounding area. Low conductivity material. Local construction for protection of disaster. Protection of volcanoes and earthquakes. 	<ul style="list-style-type: none"> Earthquake-resistant construction. Utilization of green and lightweight materials. Low conductivity and reuse materials. Protect from extreme weather. Low-emitting materials Regional material 	
Sustainable site	<ul style="list-style-type: none"> Adaptation to the extreme conditions. Adapt to topographic conditions Vegetation for building shading Life source: natural resources potential 	<ul style="list-style-type: none"> The site is safe from natural disasters and has a good view. Planting vegetation for shading, filter noise, and pollution No impact on environmental damage and safe from harmful pollution. Arrangement of outdoor space for improving aesthetics and environmental quality, water catchment areas, and bird habitats. 	
Indoor Env.Quality	<ul style="list-style-type: none"> According to the religion and culture of occupants Passive design strategy Healthy and comfortable 	<ul style="list-style-type: none"> Improve ventilation system Interior design follows the religion and culture of the occupants. Maximize natural lighting and ventilation for the comfort and health of occupants. The position of openings should consider the privacy of the neighbors and surrounding environment. Vertical gardens on balconies and terraces for providing psychological comfort, aesthetic impression, and filter of CO₂. Design of the passive solar house. 	

5. Conclusion

The architecture of North Maluku is strongly influenced by cultural and spiritual values: tangible and intangible values with a building philosophy using the anatomy of the human body in a standing position; foundation (foot), wall and room (body), roof (head). Sustainable features can be found in every part of traditional architecture in North Maluku; from design principles, materials, construction systems, passive strategies, social aspects, and philosophy. The people of North Maluku build their houses according to the possibilities and needs without architects, but they construct based on climatic considerations from old experience by passive design strategies and utilization of natural materials from the surrounding area for improving indoor thermal comfort with the basic concept of "spiritual-human-nature". The characteristics of building differ in each region according to topographic conditions and local wisdom but in the same strategy of "harmony with nature" so that the traditional architecture of North Maluku can adapt to extreme environmental conditions with local techniques: button and bond construction systems for providing a comfortable living environment of occupants. Traditional architecture in North Maluccass integrates several sustainable design principles with a passive system and it can be adopted for contemporary sustainability aspects. The usage of local material optimally, construction technique approaches based on local wisdom, integration of environmental design principles, and climate considerations that have occurred in the region over the centuries can be developed in current architectural practices.

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