Bioclimatic and sustainable features on vernacular architecture in Ternate

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Abstract. This study aims to identify the response of the vernacular building to climate and sustainability by literature study and field observations. The results show that the vernacular building in Ternate Island develops based on the characteristics of the region. The typology of building differs in each tribe following the natural condition and local culture, it has a line of equality in the building philosophy as an embodiment of the human body: feet (foundation), body (wall and room), and head (roof). Vernacular architecture in Ternate contains bioclimatic and sustainable features and can be developed to the new building concept; the basic concept is the combination of spiritual/cultural harmony, human harmony, environmental harmony, and harmony with green technology/innovation for comfort and protection of the disasters by bioclimatic architecture design strategy. This study provides insight and inspiration for sustainability in the future especially in the context of archipelago areas.

Keywords: Vernacular Architecture, Bioclimatic, Sustainable, Archipelago

1. Introduction

The Maluku Islands are located in the eastern part of Indonesia and commonly also called as Spice Islands. The Maluku Islands comprise some of the most geologically complex and active regions in the world [1]. The Moluccas Islands formed a single province. It was split into two provinces on October 12, 1999: Maluku and North Maluku (North Moluccas). Ternate is a small island in the North Maluku (Moluccas Island) and dominated by the area of volcanic mount Gamalama with a height reaches 1715 m. The population is fewer than 200,000 with an area of 111.39 km² [2]. Ternate City is an archipelago region characterized by a tropical climate. Indonesian vernacular architecture grows and expands according to the culture of traditional society. Its characteristic is influenced by the cultural manner where the architecture masterpiece resides [3]. Characteristics of traditional houses differ in each area; they are strongly influenced by the natural environment and local culture. Vernacular architecture is rich in form, traditional technology and meaning especially in the North Moluccas area including in Ternate Island, cultural influences are very strong on traditional architecture in Ternate and the surrounding area because there are different tribes yielding architecture masterpieces in the various forms of the traditional house [4]. Several studies before suggest that vernacular architecture is a model of sustainable architecture [5-7]. Vernacular architecture is the content of sustainable architecture [8-9]. The basis of sustainable construction is adopted from vernacular features[10]. The vernacular architecture successfully overcomes the challenges of adaptation to extreme local conditions and serves as a model for a sustainable design approach [11]. The bioclimatic strategy is a sustainable system of vernacular architecture. The traditional architecture uses a bioclimatic building strategy and can be considered as the basic concept for developing solar architecture in the future [12]. Traditional houses in the tropics refer to the concept of bioclimatic...
design with passive solar strategies for natural lighting and ventilation, and also usage of natural materials for protection to the hot and humid weather conditions [13]. Moreover, features of vernacular architecture have been adopted for new building concepts according to the current condition. The usage of traditional methods has been manifested in contemporary architecture in several ways such as using elements, characteristics, styles, and expressions [14]. Therefore it is very important to explore the bioclimatic and sustainable features in the past for the strategy of sustainability in the future. On the other hand, According to Gangwar [15] that it is not important to imitate the whole traditional architecture in one project but only part of the elements to inspire conformity. Several study results suggest that the materials of vernacular architecture have low environmental effects[16], even some politicians and people view vernacular architecture as a representation of an underdeveloped past and contrary to modern ideas and expectations [17]. Traditional techniques are considered inadequate and substandard, while modern materials are seen as civilized technology and a symbol of prosperity so that detailed research from various contexts is needed to explore useful features for modern buildings and further reason to elevate the image of vernacular architecture from the label "low quality"[18]. Sundaraja [19] argues that the study of vernacular architecture provides useful insights into contemporary building design by taking design inspiration from vernacular buildings following local conditions. Different climatic conditions require different responses to meet different needs so that climatic variations cause variations in architectural response in vernacular buildings [20-21]. Therefore, this study will identify the characteristics of vernacular architecture and its response to climate and sustainability in the context of the archipelago to explore useful sustainability features in the future.

2. Research Methods
This study is a qualitative research that emphasizes the identification of bioclimatic and sustainable features especially natural material, natural ventilation, orientation, adaptation to climate, and local wisdom ornament on the traditional building in the Ternate. The study area is located in eastern Indonesia in Ternate Island, North Moluccas (see figure 1). The object of study is focused on several traditional buildings, namely Falakanci house, Siko house, Sigilamo mosque, Keraton Ternate (Palace of Ternate Sultanate). The research was performed by the literature study, field observation, and depth-interview. (1) Literature study: for collecting data about the development and history of the traditional building. (2) Field observation: a direct survey in the traditional building about the material, construction, and bioclimatic features. (3) Depth-Interview: to clarify data and complement data obtained from study literature and field observations, especially about the building construction process and cultural activities related to the traditional building. The data were analyzed using architectural analysis by comparison of the building condition in past and current situations to see their change and development, and analyze the consistency of bioclimatic and sustainability features in past and present conditions.

Figure 1. Study area in Ternate Island.

3. Result and Discussion
3.1. Characteristics of Traditional Building
Vernacular architecture refers to structures that are built using locally available materials with functional styles designed to meet the needs of lay people in their time and place. Most vernacular architecture responds to regional climate [22]. This type of structure is found to be modified and
evolved over time through feedback mechanisms that already exist in the system, to reflect the environmental, cultural, and historical context in which they are there [23]. Vernacular architecture developed over the centuries has many original and interesting design practices and technologies [24]. Vernacular architecture is a climate-responsive architecture, which is an important factor in sustainability [25]. Figure 2 shows 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 pens which are also made from wood or bamboo and gamutu ropes (palm fiber) all of which function as reinforcing joints (Figure 3a). The room size has no specific standard, it 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, roof of thatched leaves tied by gamutu rope (Fig. 3b). The roof model is a pyramid-shaped roof with a high tiang raja (king pillar) (Figure 3c). The house consists of a terrace, living room, bedroom, and family/dining room, while the kitchen is separate from the main building.

![Figure 2. Traditional house of falakanci (Source: author).](image1)

**Figure 3.** Building construction: (a) Button System (b) Bond system, (c) Tiang raja (king pillar), (d) gaba-gaba (sago stem), (Source: author).

Figure 4 shows a traditional house in Siko Village (Siko House). Siko Village is located at North Ternate Subdistrict, which is inhabited by many tribes from Sulawesi. The dimension and orientation of buildings had important and sacred meaning in the past, especially during the reign of the Sultanate. The meaning is related to norms and ancestral values. For this reason, a long time ago, home locations had the following requirements: house orientation must be facing mt. gamalama because the mountain is considered to have a special and sacred value. the size of the house plan must consist of an even and odd size, as a symbol of balance in life. Building material uses natural material, namely stone foundation, wall material from gaba-gaba (sago stem) (Fig. 3d), wall and roof frames from the bamboo, roof material from sago palm leaves.

![Figure 4. Traditional house in Siko Village.](image2)
Figure 4. Traditional house of Siko (Source: author)

Figure 5 shows the Keraton Ternate building (Palace of Ternate Sultanate). This palace was built in 1257 AD using natural materials from the surrounding area. The roof material uses sago palm leaves and is then replaced with zinc. This building applies natural lighting and ventilation with an open-close window model. Figure 6 shows the Sigilamo mosque. It was built around 1606 and then rebuilt in 1818 due to fire, before the fire this mosque has also been reconstructed several times. Initially, building material used stone for wall and sago palm leaves for the roof before and then replaced with zinc in 1983. Since its inception, this building has been applying passive solar concepts by maximizing natural lighting and ventilation systems.

Figure 5. Keraton Ternate (Source: author)

Figure 6. Sigilamo mosque (Source: author).

Sigilamo mosque uses a multi-story roof model without a ceiling for maximizing cross ventilation and roof ventilation systems (see figure 7c). According to Mustamin [26] that by application of cross ventilation systems in the roof ventilation at Sigilamo, the indoor thermal conditions can reach a comfortable level. It confirms that the vernacular buildings in Ternate have been applying the principle of sustainability. Also, these buildings survive from extreme climatic conditions (mountain and ocean climate) and earthquake disasters where the Ternate region is often shaken by earthquakes. This provides a valuable lesson that local technique has good strength and is useful in the future. This result is different from the one conveyed by Oliver [17] that vernacular architecture is considered a representation of an underdeveloped past and contradicts modern ideas and expectations.

Figure 7. Ventilation types (a) Falakanci, (b) Keraton (c) Sigilamo (Source: author).

3.2. Response to Climate and Sustainable

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” [27]. Economic, environmental, social, and cultural sustainability are the pillars of sustainable development [28-29]. The bioclimatic design of buildings is one strategy for sustainable development, as it contributes to reduce energy consumption, further,
reduce air pollution and greenhouse gas emissions from conventional energy generation [30]. Bioclimatic architecture refers to the design of buildings and spaces (interior - exterior - outdoor) according to local climatic conditions for visual and thermal comfort by utilizing natural environmental sources such as sun, air, wind, vegetation, water, land, and sky. The passive solar design strategy is to integrate building elements with environmental resources naturally without mechanical devices and energy supply, which consist of three categories: passive solar heating systems, passive cooling systems, natural lighting systems [31]. Among bioclimatic features in Ternate are traditional buildings always adapted to environmental conditions such as the building location is in the potential areas of living resources, using natural materials, daylighting, natural ventilation, local construction systems, adapted to local wisdom, protection to the natural disasters with the simple construction methods. Building ornaments are usually from local characters such as flowers, birds, animals, and others.

Figure 8 illustrates the basic concepts of the traditional architecture of Ternate, which is the analysis result of the study. In the construction process is always based on the ritual ceremony to the almighty (spiritual) as a symbol of permission to build houses and the blessing to the occupants, and also usually religious values are transformed into the philosophy of building elements, such as the philosophy of king's pillar illustrated like a good relationship between occupants with the almighty so that the material of king's pillar must be from a strong and goodness wood material. Humans are respectable creatures; they must live in harmony, respect each other, and mutual help in society. The settlement is a place to build a life together and society harmony based on the culture and local conditions, and nature as a source of life that must be preserved for long-term survival.

![Figure 8. The basic concept of vernacular architecture in Ternate Island.](Source: Author elaboration)

Table 1 shows traditional architectural values in Ternate in the past. It indicates that traditional houses have many architectural values related to spiritual, human, and environmental aspects. The spiritual aspect or vertical relationship to God is a form of worship and a request for blessings. Spiritual values are very strong in the construction process; such as the ritual when starting to build a house is a form of permission and blessings, ritual constructs the king pillar or roof frame, and the ritual of entering the house. Also, spiritual value is manifested in building elements, such as the philosophy of the king pillar is a symbol of the vertical relationship to the almighty. The human aspect or human harmonious relationship that is manifested in a culture of mutual respect and care for each other. The human aspect is also realized to the philosophy of building elements as a symbol of respect for occupants such as building dimensions use human anatomy, the shaped roof in the terrace is lower than the main roof contains meaning that all guests should bow as a symbol of respect to the occupants. Natural aspects or a harmonious relationship with the environment which is manifested in the form of houses must respond to climatic and environmental conditions, utilize natural resources without damaging the environment. House location criteria are based on natural resource potential and safe from disasters because Ternate and surrounding is an area prone to natural disaster and volcano (gamalama volcano). For the building construction, the society tries to meet the safety and comfort aspects even though in a simple construction according to the conditions at the time, where the house was built using natural materials, which are available in the surrounding environment. The application
of button and bond construction techniques is one of their efforts for protection from the earthquake hazards, they believe that those techniques are more resistant to earthquake shocks and are easy to reconstruct and move. The existence of people's lives is very dependent on natural resources so that they take good care of nature. They hold strongly the philosophy of life that when humans care for nature, nature gives life to humans, when humans destroy nature, nature will bring disaster to humans. It indicates that the Ternate community is very responsive to sustainability in the past. These are very valuable sustainability values that need to be transferred to current and future generations.

Table 1. Features of a traditional house in the Past.

| Values in Past                                                                 |
|-------------------------------------------------------------------------------|
| Spiritual                                                                     |
| Religion ceremony for permission and blessing                                  |
| Philosophy building element from religious values                             |
| Tradition and ritual                                                           |
| Human                                                                         |
| Culture and local wisdom                                                       |
| Building philosophy is the human body: Feet (foundation), body (wall-room), and |
| head (roof)                                                                   |
| Occupant safety (wild animal and disaster)                                    |
| Dimension: human anatomy for harmony occupant with house                      |
| Entrance roof lower: guests stoop to respect the occupants                     |
| Built and opening house ceremonies, break bread ceremony                      |
| Custom and community ceremonies                                                |
| Nature                                                                        |
| Building location in resource potential area (mountains, valleys, and coastal |
| areas)                                                                        |
| Site adapted to the topography condition                                       |
| Natural material without iron and nail                                         |
| Response to the climate and natural condition                                  |
| Natural ventilation and lighting                                               |
| Rainwater for life and farm                                                    |

Sources: Author Elaboration

Table 2 shows the architectural features that can be adopted from traditional houses in the past to be developed into a new concept for sustainability. It portrays that traditional architecture contains features of sustainable architecture. Traditional architectural characteristics must be used as guidelines in the design of settlement and building contemporary, which combined with a green building design approach to meet the needs and expectations of today's society so that it contributes to the creation of a more sustainable built environment. Those features show that building technology is needed to realize an earthquake-resistant building in the modern day; where Ternate Island is an earthquake-prone region. Therefore, the recommendation of the basic concept for new buildings or contemporary buildings is the combination of spiritual/cultural harmony, human harmony, environmental harmony, and harmony with green technology/innovation for comfort and protection of the disasters by bioclimatic architecture design strategy.

Respect to the social, economic, environmental, and cultural conditions as pillars of sustainable development can be easily understood in traditional buildings in the Ternate Island and surrounding area. It indicates that the archipelago vernacular architecture in the North Moluccas Island offers important lessons about the relationship of harmony with nature from various perspectives of local wisdom and become real examples of sustainable architecture with the basic concept "spiritual-human-nature". The footprint of sustainability in vernacular architecture was noticed by the local population consciously. The people built their dwellings have focused on the principles of spiritual and sustainable design to improve their quality of life and safety with a simple construction system according to the limited knowledge and economic conditions at that time. Even though the conditions were limited in the past, these conditions highlight the parameters of sustainability which are very valuable compared to today, where the buildings emphasize more prestige or luxury and ignore the parameters of sustainability. Therefore, it is very important to transfer knowledge and sensitivity of sustainability from the past to the present and the future to create a life that is harmonious with nature, environment, and humans.
Table 2. Adaptation of architectural values for further.

|                | Values for Future                        |
|----------------|-----------------------------------------|
| Spiritual      | Religious activity                      |
|                | Improve worships                         |
| Human          | Local wisdom and culture sustainability. |
|                | Mutual help, cooperation and social harmony. |
|                | Integrated construction: foundation, wall, roof in a solid structure unity. |
|                | Safety & comfortable by local character building. |
|                | Disaster mitigation: community-based.    |
| Nature         | Building responsive: climate & natural disaster (earthquake, volcano, and others). |
|                | Environmental friendly / sustainable     |
|                | Green material, low energy, and low carbon |
|                | Natural resources and sustainable economy |

Sources: Author Elaboration

Conclusion

The characteristics of Ternate's vernacular architecture are a response to local climatic conditions (mountain and ocean climates effect) using natural materials and a passive solar system with a "button house" construction system for earthquake hazard protection. Building typology differs in each region following the natural condition and local culture of each tribe, but it has a line of equality in the building philosophy as an embodiment of the human body: feet (foundation), body (wall and room), and head (roof). This philosophy symbolizes designating high appreciation to human beings and as a symbol of strength and stability for the comfort and protection of occupants. The material of traditional houses uses local material from the surrounding area, namely; sago palm leaves for roof material, wall material from wood, bamboo and sago palm stem, and stack stone for the foundation. Vernacular architecture in Ternate contains bioclimatic and sustainable features and can be developed to the new building concept; the basic concept is the combination of spiritual/cultural harmony, human harmony, environmental harmony, and harmony with green technology/innovation for comfort and protection of the disasters by bioclimatic architecture design strategy.

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