Civil and Environmental Science Journal (CIVENSE)

Journal homepage: https://civense.ub.ac.id/index.php/civense/index

Original research article

Sustainability Status of Bale Tani Vernacular Architecture in Sade Village, Central Lombok Regency, West Nusa Tenggara

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ARTICLE INFO

Keywords:
Sade Village;
Bale Tani;
Sustainability of Vernacular Architecture;
Multidimensional Scaling;
Sustainability Indicators

ABSTRACT

Sade Village displays a unique settlement pattern that is influenced by geographical conditions and the needs of its residents. One of the buildings that follows the contour of Sade Village is Bale Tani, a medium-sized bale generally inhabited by families with a middle economic level. Bale Tani has undergone several changes due to the wishes of its residents, which have the potential to influence the sustainability of its vernacular architecture. This research aims to analyze the sustainability of Bale Tani vernacular architecture in Sade Village using the Multidimensional Scaling (MDS) method through the RAPFISH application, as well as carry out leverage analysis to identify indicators that influence sustainability. The results of the analysis show that the overall level of sustainability of the Bale Tani vernacular architecture is less than satisfactory, with a sustainability index value reaching 47.64%. Each of the analyzed dimensions, such as visual image, climate responsiveness, and comfortable living space, shows a low level of sustainability. Of the 18 indicators observed, nine indicators, including kamar dedare, kamar dengan to'aq, roof sheathing, wall sheathing, window openings, building floor, floor plan, roof, and wall, are the dominant factors in the sustainability of Bale Tani vernacular architecture.

1. Introduction

Central Lombok is one of the areas in West Nusa Tenggara that has a lot of art [1]. Tourist villages that are now starting to be able to develop the rural economy in Lombok are Sade Village, Banyumulek Village, and Sukarare Village. Sade is a tourist village that is more famous than Sukarare [2].

Sade Village is a tourist village that is one of the popular destinations on Lombok Island [3]. Sade Village has added several additional buildings, including a mosque and Bale Dagang which is used to sell souvenirs to support the arrival of visitors. This village is known as a tourist destination because its residents still maintain the integrity of the culture and lifestyle inherited from their ancestors, such as the shape of buildings, customs, dances, musical games, and clothing styles, which are still traditional and are still preserved today [4].

Sade Village is one of the traditional villages in Central Lombok where the daily life of the people is still very closely tied to the traditions of the Sasak people in the past. The people of Sade Village choose to continue *pengadiq adiq* or traditions passed down from generation to generation by maintaining customs [5]. The building structure in the Sade traditional house consists of 51 Bale Tani units, 6 Bale Alang units, and 9 Berugaq units. In particular, to meet the need for larger space, they developed a type of Bale Tani building called Bale Bontar with 13 units. Apart from that, 2 Bale Tani units are used as Bale Kodong for weddings [6].

Sade Village has a unique settlement pattern that is greatly influenced by geographical conditions and the needs of its population. The traditional architecture built by the Sasak people of Lombok in Sade village contains certain symbols by their belief in the relationship between God and humans, humans and their ancestors, and humans and each other. These buildings are also built according to their function in the environment [7].

Sade Village has a hilly contour as a background; this village has developed a settlement structure that follows the available land. When the land on the hill becomes denser, residents build houses on other hills, and this process continues until the hills are used up. The village territory is divided using a bamboo fence, and building houses on the hill starts from the bottom to the top. This pattern reflects the close relationship between residential buildings and the arrangement of other supporting buildings, such as barns, meeting places, mosques, security posts, stables, wells, and tombs. Circulation within the village is less regular, with

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doi: 10.21776/ub.civense.2024.007.02.5
Received: 28 May 2024; Revised: 21 Jun 2024 Accepted: 31 Oct 2024
E-ISSN: 2620-6218

unpaved roads being difficult to pass, partly due to the very poor economic condition of the population.

The term sustainable architecture' emerged a little earlier in the 1970s and gained significant popularity during the 1990s, which was associated with the construction of the United Nations headquarters in New York, United States. Sustainable architecture is about building a healthy built environment with the principles of ecological and resource efficiency [8].

One of the distinctive architectures of Sade Village is Bale Tani. Bale Tani is a medium-sized bale, approximately 5 m x 7 m, which is usually occupied by families with a middle economic level. In general, this bale is used by the Sasak people, who work as farmers and are located in contour areas. In front of the Tani Bale, there is usually a Bale Dagang, and the distance between the two is very narrow so that when walking in the space between the two, people can squeeze together. This allows the process of selling merchandise to be more intensive.

Architectural design presentations are growing rapidly [9]. Over the years, Bale Tani has experienced several changes in line with the times. In 2023, the total number of Bale Tani that still maintains its original type in Sade traditional houses will be 33 units from the initial 36 units. This change occurred due to the era of globalization, which influenced changes in the number of Bale Tani itself and the changing needs of its users. This change was also triggered by the desire of the Sasak people in Sade Village to improve their quality of life. Apart from that, climatic factors also play a role in the physical changes and function of the Bale Tani room. This factor is the reason and goal of the Sasak people in innovating every aspect of their Bale Tani.

Understanding the scientific and technical facts necessary to design renewable and sustainable energy policies for development is essential to promoting sustainable concepts adapted from vernacular architecture [10]. These changes will certainly affect the sustainability of Bale Tani's vernacular architecture. Oliver's definition of vernacular architecture encompasses a variety of meanings, from constructions built or adapted by people for their daily needs wherever and whenever to the more limited definitions of traditional houses, pre-industrial structures, and buildings built by hand. The interpretation of vernacular architecture based on processes of change and adaptation is a new idea that is less favored by researchers in the field of vernacular architecture and has many opportunities for contemporary intervention [11].

The term vernacular architecture was introduced by Rudofsky in 1964 through a photo exhibition featuring works of vernacular architecture in New York City [12]. This term comes from the word Verna (from Latin), which means domestic, Indigenous, native slave, or home-born slave, which was chosen by Rudofsky to classify local architecture, which is generally residential [13], [14], [15].

The sustainability status of vernacular architecture using multidimensional scaling can provide deep insight into various aspects of vernacular architecture and enable holistic evaluation of the various factors influencing sustainability in this context. The multidimensional scaling method allows a more complex analysis by considering many dimensions, including social, economic, and environmental aspects of vernacular architecture. By understanding this sustainability status, we can identify challenges and opportunities to improve and develop vernacular architectural practices to make them more environmentally friendly and sustainable.

Based on these changes, the researchers proposed three dimensions to be analyzed, namely the visual image dimension, the climate-responsive dimension, and the comfortable living space dimension. The determination of these three dimensions is also based on the principles of eco-cultural logic, which includes aspects of visual image, climate responsiveness, and livable, comfortable spaces to achieve sustainability in architecture [16].

Visual images in architecture not only reflect the impression or meaning perceived by individuals after seeing a particular structure or area, but also reflect the culture and human character involved in the design and use of buildings. Visual images are a characteristic of an entity and can also be used to facilitate the identification of the entity [17]. This image is formed through elements such as symbols, signs, shapes, and colors received through the observation process, as well as through discussions between the architect and the client. In the visual image section of Bale Tani, the variables observed are the spatial system in the form of the floor plan of Bale Tani, the physical system in the form of the roof, doors, windows, and walls of Bale Tani, and the stylistic system in the form of ornamentation in Bale Tani. Visual images can be understood by understanding the physical characteristics of buildings. An in-depth understanding of the physical characteristics of buildings is very important in understanding visual images, which in turn influence how people respond and draw conclusions about the buildings they observe [18], and is useful in dealing with climate-responsive aspects.

The climate-responsive dimension is the main element that must be present in sustainable architecture because it must be able to reduce energy consumption and avoid environmental degradation due to the presence of the building. In wetter winters, 90% of residents in traditional homes feel comfortable, while only 50% feel comfortable in modern homes. CO concentration$_2$ high levels were detected in houses with tight buildings (1800–1900 ppm) due to a lack of adequate ventilation [19]. Sustainability in architectural traditions must include elements of climate response, reflecting an understanding of architectural principles that are environmentally friendly and efficient in the use of energy from building sources. In Bale Tani, there are thermal comfort factors such as building orientation [20], window openings, wall color, eaves [21], [22], [23], building floors [24], and vegetation around buildings [25]. This ability is also greatly influenced by the level of knowledge, technology, and skills that existed during the construction of the source building. Apart from that, the forms and efforts to adapt to this climate are also influenced by construction habits and traditions that already exist in local communities.

The dimensions of comfortable living space in Bale Tani refer to the thermal comfort inside the building. Thermal comfort includes psychophysiological sensations and experiences that arise when harmony is achieved between body heat, activity, and energy changes between humans and the environment at a certain time and moment [26]. In Bale

Tani, in the context of the dimensions of comfortable living space, it is divided into six parts, each of which has a special function, such as *oraq-oraq, kamar dengan to'aq*, room for children or guests, *kamar dedara, pa'on*, and *nenting*. Determination of thermal comfort is carried out by asking residents or local people who have or are currently occupying Bale Tani in Sade Village regarding the temperature sensation felt in each room. Thus, the dimensions of comfortable livable space at Bale Tani include subjective evaluation of thermal comfort by the occupants or users of the space.

These three dimensions can reflect the local community's views on the physical aspects of the building in the context of architectural sustainability over time. The results of this evaluation will provide insight into how the dimensions and their constituent elements contribute to future architectural developments. This research is a step to explore the physical potential of the Bale Tani building as a source of learning and development in the context of sustainable architecture. Combining modern, climate-responsive approaches with lessons from vernacular architecture, researchers can develop innovative and sustainable design solutions to reduce the impact of global warming and increase energy efficiency in buildings.

2. Method

This research uses a quantitative approach to analyze the sustainable passive design of Bale Tani by examining in detail its physical characteristics, including the top, middle, and bottom of the building, then developing Bale Tani in three main dimensions: visual image, climate response, and comfortable living space. The Multi-Dimensional Scaling (MDS) technique aims to analyze the relative impact of each dimension on the phenomenon being studied and rank the influence of each dimension. This analysis is deepened with the RAPFISH application, which can identify the main factors that contribute to sustainability based on each dimension.

Building samples were determined through purposive sampling according to predetermined criteria [27]. The sample selection criteria were based on the authenticity of the building facade which remained unchanged and the condition of the interior which was still in its original condition. Figure 1 shows diagram that used purposive sampling with an initial population of 33 Bale Tani buildings and 150 heads of families in Sade Village. The initial step is to determine guides and resource persons who are important for the smooth running of research in the village, followed by obtaining permission from the hamlet head and establishing survey facilities. Only buildings that are still occupied and the owner permits are the objects of research. Data was collected through documentation and interviews with questionnaires and then tabulated for further analysis. 11 buildings from 33 buildings were selected as samples, while 50 local people consisting of 31 men and 19 women from 150 heads of families with an age range of 17-45 years were selected as respondents. Sample selection was based on the representation of the Bale Tani building type, ease of permission from the owner, and input from sources.

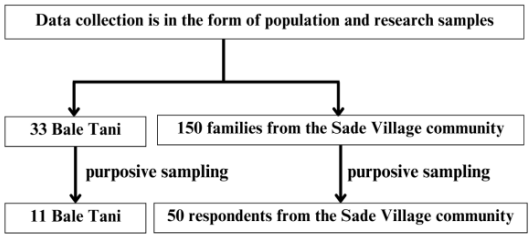

Figure 1. Diagram of data collection

This method analyzes all aspects simultaneously to produce a scale vector. RAPFISH provides a fast and comprehensive picture of the analyzed conditions with sufficient accuracy regarding the sustainability status of the resource, which can ultimately be used as a basis for formulating appropriate policies. RAPFISH is a Multicriteria Analysis (MCA) approach that operates an ordination technique (placement in a sequence of measurable attributes) using Multidimensional Scaling (MDS) [28], [29], [30]. The results of this evaluation will identify the physical elements that make up the building and their level of sustainability in the form of a rating. This data will provide insight into the physical potential of this building for architectural learning and development purposes.

The RAPFISH technique utilizes a scaled, constrained multidimensional ordination to position data points within an evaluation space. Results can be displayed as either a two-dimensional plot or a one-dimensional rank order within each evaluation field. A key advantage of RAPFISH is its transparency, as overall results are shown in kite diagrams, allowing comparisons across different locations and periods (including future projections) [31]. The RAPFISH application can also carry out leverage factor analysis or driving factors, which function to find out what factors influence increasing the level of sustainability of each dimension of the sustainability of the Bale Tani vernacular architecture.

This research was carried out in six stages. The first stage is to determine the four dimensions that will be analyzed. These three dimensions include visual image (6 attributes), climate responsiveness (6 attributes), and livable space (6 attributes). The second stage is scoring sustainable aspects in each dimension (on a scale of 0-2) from the results of the local community questionnaire. The third stage presents the scoring results on an ordinal scale using Multi-Dimensional Scaling (MDS) analysis using RAPFISH. The fourth stage is to determine the analysis factors and dominant factors in the form of a diagram from these three dimensions. The fifth stage is identifying sensitive attributes using sensitivity analysis (leverage analysis). This identification is used to determine which attributes influence each dimension. The final stage is the depiction of the sustainability index scale in a kite diagram [29].

Each dimension is measured using indicators that are assessed based on the scientific assessment by the scorer. The score for each indicator from each respondent is mapped into a scale range of 0 to 100, where 0 indicates a low level (poor quality) and 100 indicates a high level (very good quality). The scores given are then rearranged and simplified into numbers that are easier to use for sustainability analysis [32], [33]. The results of the sustainability analysis produce a sustainability index for each dimension in percentage form. The sustainability index in each dimension is measured on a value scale between 0 and 100%, with the criteria in Table 1.

Table 1. Continuous index scoring value

Scale	Information
0.00 – 25%	Not sustainable
25.1 – 50%	Less sustainable
50.1 – 75%	Quite sustainable
75.1 – 100%	Very sustainable

The value index for each dimension is presented in a Kite Diagram. To increase the value of the sustainability index in the future, a leverage analysis was carried out to determine the value of factors that influence sustainability in each dimension. The assessment of these factors is in the range of 1-3%. If the factor value is less than 1%, it is considered to have no influence, whereas if the value exceeds 3%, it is considered a dominant factor that greatly influences sustainability [29].

3. Result and Discussion

The sustainability dimensions of passive design at Bale Tani are divided into three, namely the visual image dimension, the climate responsive dimension, and the comfortable living space dimension. The following is a discussion of each dimension of passive design sustainability.

3.1. Visual Image Dimensions

To understand the visual image of a building, it is important to recognize its physical characteristics, such as topography, type, structure, and tectonic elements. It is important to assess the function, structure, and symbolic value of the building. The analysis approach includes spatial, physical, and stylistic systems. Examining Bale Tani, the variables observed include floor plan, roof, doors, windows, walls, and ornamentation. Understanding a building's physical characteristics helps determine necessary changes, particularly in the context of climate response.

Table 2 shows the components, explanations, and values to determine the opinions of respondents, especially the local community of Sade Village, in understanding the dimensions of the visual image in Bale Tani.

Based on the results of a questionnaire conducted by the author with the people of Sade Village regarding the visual image of Bale Tani is as follow Figure 2.

Figure 2 shows a diagram of the visual image elements of Bale Tani that have physical characteristics that form the visual image of Bale Tani that are sequentially recognized and observed by the respondents, namely the roof, walls, floor plan, doors, ornamentation, and windows.

3.2. Dimensions of Climate Responsiveness

The traditional buildings built by Indonesian people are the result of instincts inherited from their ancestors, with the main aim of creating comfortable spaces. This is a reflection of experience and a deep understanding of the need for comfort and function in everyday life. Adaptation to climate is an important factor in efforts to create comfort, and since ancient times, humans have tried to create shelter that suits the local climate. Traditional buildings also reflect a thoughtful response to the characteristics of the surrounding climate.

Human life depends on the need to have a shelter that is suitable for the climate of the region where they live. The level of success in adapting to the climate is influenced by local community knowledge and construction technology, as well as the availability of local building materials. The ability to respond to climate is reflected in various aspects of traditional architecture such as form, construction, materials, orientation, and surrounding environment, which significantly influence the thermal comfort of occupants.

The importance of climate response in traditional architecture creates potential as a source of knowledge for developing sustainable architecture in the future. Evaluation of thermal comfort in traditional buildings is carried out by collecting data through direct measurements and occupants' opinions, which is the basis for analyzing factors that influence thermal comfort such as building shape, construction, materials, orientation, and the surrounding environment.

Climate responsiveness is a key element in sustainable architecture, which can reduce energy consumption and prevent environmental degradation. In Bale Tani, the climate-responsive aspects used consist of building orientation, roof sheathing, wall sheathing, window openings, building floors, and external environmental layout. By adopting these climate responsive aspects, sustainability in the architectural tradition must include a response to the climate, which reflects an

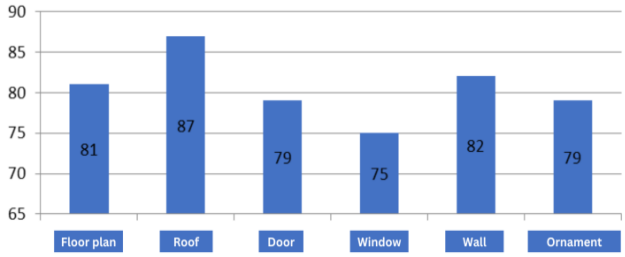

Figure 2. Diagram of Bale Tani's visual image elements

Table 2. Components for visual dimensions

Component	Explain	Mark
Floor plan	A visual element that displays the structure of space in two dimensions by showing the division of space in one building.	0 = Not attractive 1 = Neutral 2 = Interesting
Roof	A visual element in the form of a roof protects the building and becomes a special feature that attracts respondents.	
Door	The visual element is a door, which is a visual representation of an opening or gate in the wall of a building that allows entry or exit from a room or area.	
Window	The visual element is a window that becomes an opening in the wall to make it easier for light and wind to enter the room.	
Wall	Visual elements in the form of vertical structures limit or divide space within a building.	
Ornament	Visual elements that function as decoration to beautify the appearance of the building so that it attracts respondents.	

understanding of architectural principles that are environmentally friendly and efficient in energy use. It is also influenced by the knowledge, technology, skills, habits, and construction traditions of local communities, as well as the use of local building materials to create climate-responsive and sustainable buildings.

Table 3 shows the components, explanations, and values to determine the opinions of respondents from the local community of Sade Village in understanding the dimensions of climate responsiveness in Bale Tani.

Based on the results of a questionnaire conducted by the author with the people of Sade Village regarding Bale Tani's climate response, they are as follow Figure 3.

Figure 3 shows a diagram of respondent's opinions on climate response, which are known to be the physical characteristics that influence Bale Tani's climate response, sequentially recognized and observed by respondents, namely roof sheathing, window openings, wall sheathing, building floors, external environmental layout, and building orientation.

3.3. *Dimensions of Comfortable Living Space*

The traditional buildings built by Indonesian people are the result of instincts inherited from their ancestors, with the main aim of creating comfortable spaces. This is a reflection of experience and a deep understanding of the need for comfort and function in everyday life. Adaptation to climate is an important factor in efforts to create comfort, and since ancient times, humans have tried to create shelter that suits the local climate. Traditional buildings also reflect a thoughtful response to the characteristics of the surrounding climate.

The third dimension in architectural sustainability is comfortable living space, which focuses on thermal comfort within the building. Thermal comfort involves harmony between body heat, activity, and energy changes between humans and the environment at any given time. Factors such as air temperature, humidity, radiation, and wind movement, as well as subjective factors such as body metabolism and clothing, influence thermal comfort. Indonesia has a humid tropical climate; adaptation to these conditions is reflected in traditional designs such as steep roofs, use of open spaces, and natural air circulation.

Table 4 shows the components, explanations, and values to find out the opinions of respondents, especially the local community of Sade Village, in understanding the dimensions of comfortable livable space in Bale Tani.

In the calculation table below, you can see the opinions of respondents regarding the comfort of Bale Tani's living space.

Figure 4 shows a diagram of respondents' opinions about comfortable living spaces, which shows that residents are more comfortable in *kamar dedara* and *kamar dengan to'aq*. *Nenting* and *Pa'on* are the last rooms in terms of comfort because *Pa'on* functions as a kitchen, so it produces more heat.

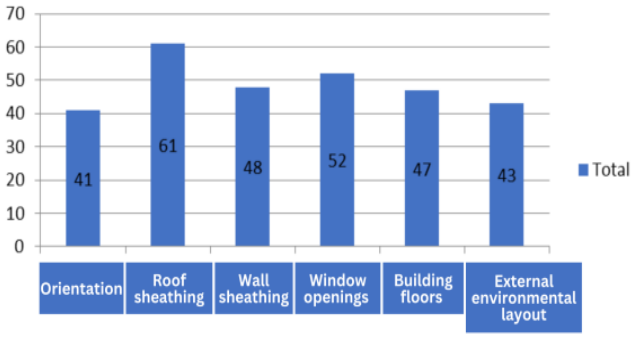

Figure 3. Diagram of respondents' opinions on climate response

Table 3. Components for climate responsive dimensions

Component	Explanation	Mark
Orientation	The direction the building faces influences the level of comfort at Bale Tani in Sade Village	0 = Very no effect 1 = Influential 2 = Very influential
Roof sheathing	Architectural elements that function to protect direct sunlight and rainy weather and bright colors can reflect heat so that it is not absorbed into the building	
Wall sheathing	Architectural elements that function to increase thermal comfort in buildings by utilizing passive design principles and efficient use of natural resources	
Window openings	Architectural elements that function to receive light and wind into the room so that they can provide thermal comfort for residents	
Building floors	Architectural elements that can give the impression of interesting height differences that can influence the distribution of natural light and air circulation in the room. Floor materials can also provide a unique visual impression and influence the aesthetics and comfort of a space.	
External environmental layout	The vegetation around the building plays a role in providing comfort for the occupants of the house.	

Table 4. Components for comfortable living space dimensions

Component	Explanation	Mark
Kamar dedara	*Kamar dedara* is a place for girls.	0 = uncomfortable 1 = neutral 2 = comfortable
Nenting	*Nenting* which is considered a holy place from the entrance to the back barrier. In the end, several heirlooms or items are considered sacred, while the middle is used as a place to give birth or place the body	
Pa'on	*Pa'on* is a place to cook	
Kamar dengan to'aq	*Kamar dengan to'aq* as a bed for parents	
A place for children/guests	The children's/guest area is a room for boys to sleep and receive guests from outside	
Oraq-oraq	*Oraq-oraq* is a long, narrow space located at the front, used only as a gap between the front partition and Bale Tani.	

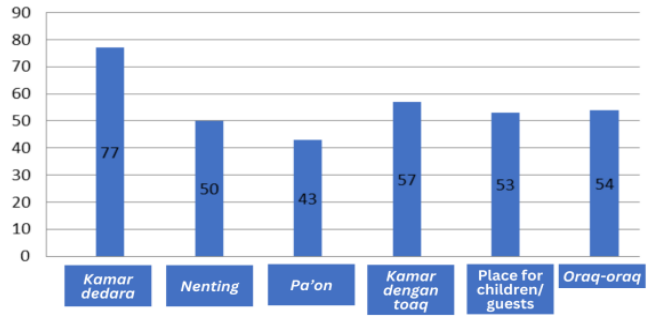

Figure 4. Diagram of respondents' opinions about comfortable living spaces

3.4. *Analysis of Sustainable Dimensions using RAPFISH*

The results of the evaluation using the RAPFISH method will show the level of sustainability of the Bale Tani vernacular architecture. This approach is suitable for evaluating the actual state of Bale Tani from a conservation perspective to ensure that Bale Tani represents a sustainable source of local knowledge and traditional wisdom. Therefore, knowledge about the sustainability of Bale Tani vernacular architecture can be applied in the development of contemporary architecture today by considering the factors that drive it. To evaluate the interaction between these factors in their dimensions, factor analysis was used, which collected data through surveys distributed to residents in Sade Village. Based on the recap calculation of the factor analysis values for the visual image dimensions, the average values obtained are as in Table 5 and Figure 5.

Figure 5 shows that the element in the visual image dimension that is most attractive and easy to remember by residents is the roof. This is due to the uniqueness of the Bale Tani roof which is larger than other buildings in Sade Village. Therefore, knowledge about sustainable architecture related to the visual image of the Bale Tani roof structure is important to develop the aesthetic composition of the roof shape so that it can represent the visual image of Bale Tani when applied in contemporary architecture.

Table 5. Factor analysis of visual image dimensions

Factor Analysis	Percentage of Visual Image (%)	Average value
Floor plan	16.8	1.62
Roof	18.0	1.74
Door	16.4	1.58
Window	15.5	1.50
Wall	17.0	1.64
Ornament	16.4	1.58

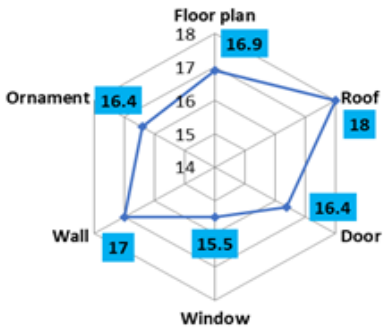

Figure 5. Dominant factors in visual image dimensions

Based on the recap calculation of the factor analysis values for the climate responsive dimension, the average values obtained are as in Table 6 and Figure 6.

Figure 6 shows that the most determining factor for Bale Tani in responding to the surrounding climate is appropriate roof sheathing. Furthermore, a quite significant factor influencing climate responsiveness is window openings. The sustainable architectural knowledge of the Bale Tani building in responding to the climate in the sequence is roof sheathing, window openings, wall sheathing, building floors, external environmental layout, and orientation.

Based on the recap calculation of the factor analysis values for the comfortable living space dimensions, the average values are obtained in Table 7 and Figure 7.

Table 6. Analysis of dimensional factors for climate responsive

Factor Analysis	Percentage of Climate Responsive (%)	Average value
Orientation	14.0	0.82
Roof sheathing	20.9	1.22
Wall sheathing	16.4	0.96
Window openings	17.8	1.04
Building floor	16.1	0.94
Organize the external environment	14.7	0.86

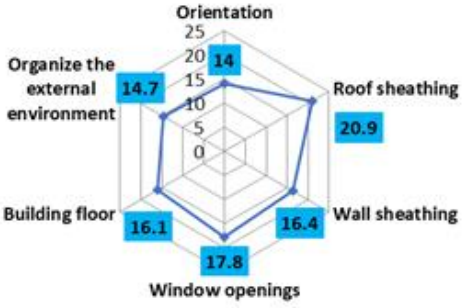

Figure 6. Dominant factors in climate responsive dimensions

Table 7. Analysis of dimensional factors for comfortable living space

Factor Analysis	Percentage of Comfortable Living Space (%)	Average value
Kamar dedara	23.1	1.54
Nenting	15.0	1.00
Pa'on	12.9	0.86
Kamar dengan to'aq	17.1	1.14
Children/guests place	15.9	1.06
Oraq-oraq	16.2	1.08

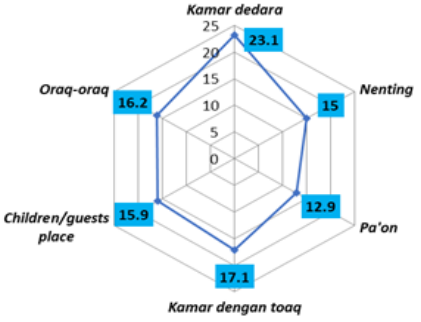

Figure 7. Dominant factors in the dimensions of comfortable living space

Figure 7 shows in sequence that residents feel more comfortable in *kamar dedara, kamar dengan to'aq, oraq-oraq,* children/guest area, *nenting,* and *pa'on.*

In the Bale Tani building, the visual image dimension is dominated by the roof, which is the most prominent and easily remembered by residents because of its greater uniqueness compared to other buildings in Sade Village. Therefore, knowledge of sustainable architecture related to the visual image of the Bale Tani roof is very important to develop an aesthetic roof composition that represents the visual image of Bale Tani in contemporary architecture. In the climate-responsive dimension, the most significant factors in responding to the climate around Bale Tani are appropriate roof sheathing and window openings. Knowledge of sustainable architecture in Bale Tani buildings emphasizes the importance of these factors in adapting to the climate. Finally, in the dimension of comfortable living space, Bale Tani residents generally feel comfortable in *kamar dedara* followed by *kamar dengan to'aq*. This shows that the design and characteristics of the building have a significant influence on the quality of the occupants' experience.

The three dimensions were known both from factor analysis and average values, and then a sustainability dimension analysis was carried out using RAPFISH by coordinating using the Multi-Dimensional Scaling (MDS) method.

Figure 8 shows that the sustainability level of Bale Tani vernacular architecture is 47.64% or less sustainable. The index categories and sustainability status can be assessed with the following information: An index value of 0.00 – 25.00% is in the bad category (not sustainable), an index value of 25.01 – 50.00% is in the poor category (less sustainable), an index value of 50.01 – 75.00% is in the sufficient category (quite sustainable), and the index value of 75.01 – 100.00% is included in the good category (very sustainable).

The level of sustainability of Bale Tani's vernacular architecture is in the less sustainable category. This is because Bale Tani is a cultural relic of the Sasak tribe in the past, so in terms of calculations, the results also show the actual field facts that Bale Tani was built with low technology, using the availability of natural materials around and the knowledge of the time.

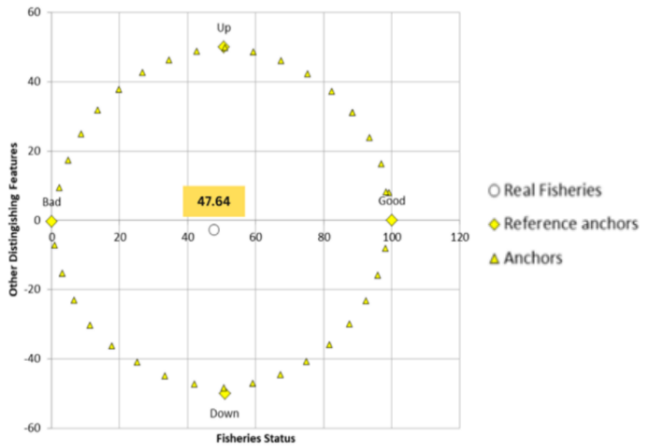

Figure 8. Sustainability architecture vernacular Bale Tani

Based on analysis using Multidimensional Scaling (MDS), the sustainability level of Bale Tani vernacular architecture is at 47.64%, which is included in the less sustainable category. However, this assessment needs to be reviewed by considering various theories of architectural sustainability. Bale Tani, as the cultural heritage of the Sasak tribe, reflects the principles put forward by Paul Oliver about vernacular architecture being inherently sustainable, including the use of local materials and adaptation to the local climate [34]. The utilization of indigenous natural resources and basic technology aligns with Ken Yeang's bioclimatic theory [35]. Adaptation to climatic conditions and using local materials shows optimal environmental adaptation, as explained in Amos Rapoport's theory [36].

Despite the low MDS score, Bale Tani may have a higher level of sustainability if assessed using the sustainability concept. This shows that assessing the sustainability of vernacular architecture such as Bale Tani requires a more comprehensive approach that not only relies on conventional metrics but also considers the cultural, social, and ecological values inherent in vernacular architecture.

This research continues with the use of leverage analysis, which aims to understand the factors that influence the sustainability of Bale Tani vernacular architecture. The assessment of these factors ranges from 1-3%. If the factor value is less than 1%, then the factor is considered to have no influence, while if the value is more than 3%, then the factor is considered a dominant factor that greatly influences sustainability [29].

Figure 9 shows that the dominant factors in the sustainability of Bale Tani vernacular architecture can be seen, namely *kamar dedare* (4.58%), *kamar dengan to'aq* (3.15%), roof sheathing (4.71%), wall sheathing (3.31%), window openings (3.54%), building floor (3.15%), floor plan (3.25%), roof (3.82%), and wall (3.32%).

The contribution of the role and reference to knowledge of sustainable architecture can be seen from the sustainability dimensions of Bale Tani vernacular architecture by using the RAPFISH application and used as a screen diagram for the value of each dimension as in Figure 10.

Figure 10 shows that the dimension contribution with the greatest value is in the climate responsive dimension with a value of 42.11%. The dimension behind it is followed by the dimension of a comfortable living space with a value of 36.03% and the visual image dimension with a value of 31.54%.

The results from Table 8 show that the level of sustainability of the Bale Tani vernacular architecture in Sade Village is less than 50%. This is caused by the low visual image dimension index, only 31.54%. This condition shows that people currently tend to ignore Sasak traditions in building their houses, switching to modern houses, which makes it difficult to implement designs from Bale Tani and improve their sustainability.

In research conducted by [37], making the Huma Gantung Buntoi object a useful source of information in the form of published journals about local wisdom in architecture that is sustainable, harmonious with nature, and energy efficient—knowledge that can be applied to the design of modern

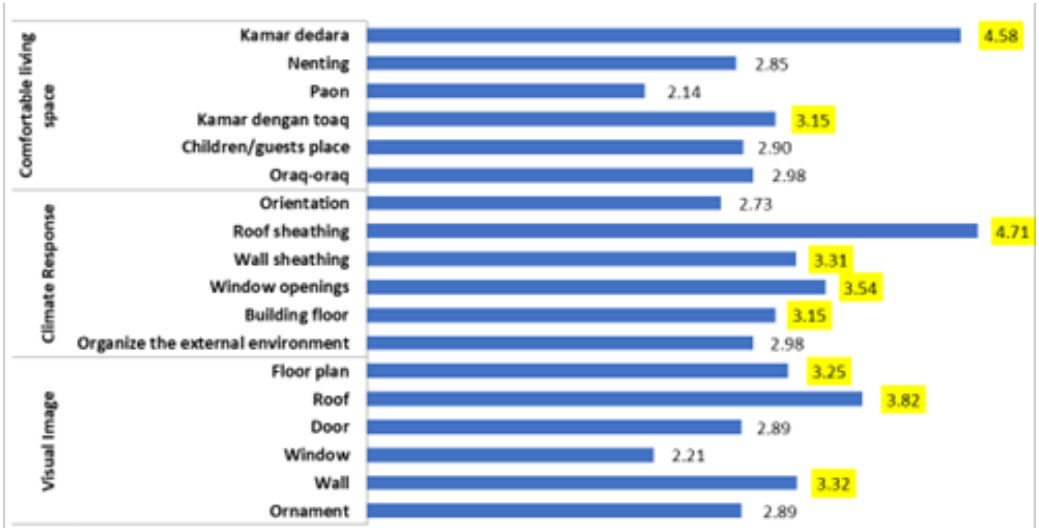

Figure 9. Leverage analysis sustainability architecture vernacular Bale Tani

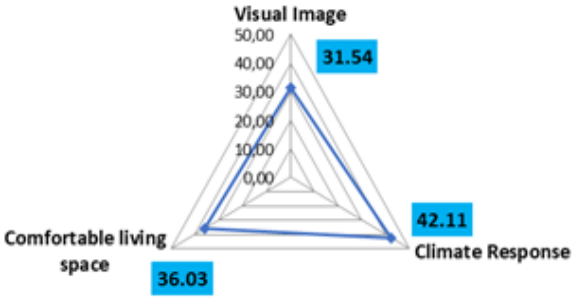

Figure 10. Contribution of each dimension to the sustainability of vernacular architecture

Table 8. Results of analysis of the sustainability dimensions of vernacular architecture

Dimensions of Sustainability	Mark	Information
Visual Image	31.54%	Less sustainable
Climate Response	42.11%	Less sustainable
Comfortable living space	36.03%	Less sustainable

housing—is one way to address the lack of sustainability status of vernacular buildings.

In research conducted by [32], increasing positive aspects and reducing negative ones that affect an object's sustainability value by referring to dominant and influential features is how to improve sustainability status in the future (leverage). It is necessary to carry out architectural design interventions by combining traditional and modern concepts so they are more attractive to the public.

Revitalizing and improving the sustainability of vernacular architecture such as Bale Tani in Sade Village can be done by adopting principles from previous research and integrating them with the latest research findings. The following are several ways to adopt previous research in the latest research, namely: first, adopting local wisdom in architecture that is sustainable, energy efficient, and harmonious with nature as discussed by [37], by utilizing Bale Tani typology observation units such as building orientation, roof sheathing, wall sheathing, window openings, building floors, and external environmental layout as design inspiration. Second, considering the multidimensional dimensions of sustainability (ecological, economic, socio-cultural, and technological) as in [32], which focuses more on the dimensions of visual image, climate responsiveness, and livable, comfortable spaces. Third, referring to the dominant factors of Bale Tani's sustainability (*kamar dedare*, *kamar dengan to'aq*, roof sheathing, wall sheathing, window openings, building floor, floor plan, roof, and wall) identified in this research and maintaining these aspects. Fourth, carry out architectural design interventions by combining traditional concepts from Bale Tani and modern concepts that are more popular with society today, as suggested by [32], to improve the dimensions of the visual image which is a weakness. Fifth, developing sustainable, comfortable, and appropriate local culture housing by adopting the principles of climate responsiveness from Bale Tani and integrating them with modern design.

4. Conclusion

The sustainability dimension of passive design in Bale Tani in Sade Village shows a low level of sustainability, with a value of 47.64%. This is because Bale Tani is a cultural heritage of the Sasak tribe in the past, which was built with simple technology and limited knowledge at that time. Even though Bale Tani has a low MDS score, it may demonstrate a higher level of sustainability when evaluated using the sustainability concept. This indicates that assessing the sustainability of vernacular architecture like Bale Tani requires a more comprehensive approach. Such an approach should not only depend on conventional metrics but also on the cultural, social, and ecological values inherent in vernacular architecture.

It is known that the visual image dimension is the lowest value, so the solution to overcome this is to intervene in architectural design by combining traditional concepts from Bale Tani and modern concepts to make it more attractive. Overcoming the low value found in the climate responsive dimension and the comfortable living space dimension achieved by integrating with modern design to create sustainable, comfortable, and appropriate local culture housing.

Revitalizing and increasing the sustainability of vernacular architecture such as Bale Tani in Sade Village can

be done by adopting local wisdom in architecture that is sustainable, energy efficient, and harmonious with nature by utilizing Bale Tani elements as design inspiration. Apart from that, it is necessary to consider the multidimensional dimensions of sustainability, including the dimensions of visual image, climate responsiveness, and comfortable, livable space. Referring to the dominant factors of Bale Tani's sustainability, such as *kamar dedare*, *kamar dengan to'aq*, roof sheathing, wall sheathing, window openings, building floor, floor plan, roof, and wall maintenance, these aspects are also important. Architectural design interventions by combining traditional Bale Tani concepts and modern concepts that are of interest to society today can be carried out to increase the dimensions of the visual image. Finally, adopting the principles of climate responsiveness and comfortable livable spaces from Bale Tani and integrating them with modern design so that the residence is sustainable, comfortable, and appropriate to local culture.

Author Declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

Funding

No funding information from the authors.

Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

Additional information

No additional information from the authors.

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