Sustainable Aspects of Wall Constructions of Traditional Houses: Insights from the Bajau Tribe House, Indonesia

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Abstract

The Bajau tribe is highly dependent on Nature because of their profession as fishermen. Based on their experiences, the Bajau people went through a process of trial and error in adapting their residential coastal buildings to the more extreme conditions. This research examines the local wisdom of the traditional Popondok house of the Bajau tribe, specifically in terms of the wall material construction technique and the selection of wall materials as a means of defense and utilization against extreme coastal weather. It proposes design proposals related to installation techniques of wall elements in contemporary housing issues.

The research uses a case study with a descriptive qualitative approach. Data collection for the case study employs a literature study with Iwamura's 3G approach.

It produces a design proposal for wall material installation techniques in contemporary houses taking inspirations from the local wisdom of the Popondok house of the Bajau tribe.

Keywords: Popondok, Traditional house of the Bajau Tribe, Wall material, Wall installation technique, Sustainability.

Introduction

Urbanization is closely related to current sustainability issues. According to the 2010 census in Indonesia, 49.8% of the Indonesian population lives in urban areas (Winayanti, 2016). By 2050, two-thirds of Indonesia's population is expected to be represented by this figure (Winayanti, 2016). Smaller families and fewer children are some of the signs of how urban society is changing to reflect modern life (Siregar, 2019). Based on these trends, newly married couples require separate living quarters in terms of housing (Siregar, 2019). As a result, today, the demand for individual houses in big cities is increasing due to urban migration. This high demand for individual dwellings leads to a scarcity of available building land due to the inefficiency between the number of occupants and the occupied building areas. As a result, there will be a need to maximize the utilization of interior spaces to curb the rapid pace of development. The second issue related to vertical building occupancy is the diverse characteristics of the needs of each family member (Setyoningrum, 2009). Therefore, flexible

design of residential spaces is essential, allowing each individual or family to create spaces according to their evolving conditions and needs (Setyoningrum, 2009).

The SkyVille apartment complex by WOHA, for example, has a flexible layout scheme with three different floor plans for each flat (*SkyVille@Dawson and SkyTerrace@Dawson Are Launched - Singapore History*, n.d.). This is built on column-free and beam-free apartment spaces, reducing waste and accommodating diverse family sizes and lifestyles, such as home/office combinations (WOHA, 2016). This concept addresses the multi-generational flexibility issue necessitated by the dense population (Decor, 2016). Similarly, partitions instead of permanent walls of most of singapore houses offer flexible living spaces.

Creating partition designs for spatial flexibility requires drawing inspiration from the sustainable elements of traditional houses that have proven their longevity. In this context, the Bajau community in Indonesia has long considered flexibility in creating dwellings that can withstand extreme maritime weather. In ancient times, with limited knowledge, Bajau people have tried to ensure their survival. Originally, people have moved between seas in search of natural resources and favorable weather conditions. Eventually, they have settled in one place, forming communities to sustain their families (Salipu et al., 2022b). This demonstrates that the Bajau people have had a notion of sustainable living since ancient times, albeit through trial and error, which is distinctly different from contemporary methods. The aim of this paper is to unravel these principles and practices so that they can be re-utilized in contemporary housing.

Its objectives are as follows.

1. To identify the sustainability elements that constitute the local wisdom of the traditional Popondok Bajau houses, specifically regarding the installation techniques and material selection for walls, as strategies for withstanding and utilizing extreme maritime weather.
2. To propose a design solution concerning the installation techniques of wall materials in the context of present-day housing issues.

Theoretical Framework: Understanding Sustainable Architecture

Global issue: Protection of the global environment (low impact)

According to Iwamura (2005), energy consumption of building construction and operation must be immediately minimized to meet the requirements of COP3 (Certificate of Proficiency) concerning efforts to reduce CO2 and other GHG emissions. This includes efforts to produce as little waste as possible. For example, a significant amount of concrete is generated during both building construction and demolition. Therefore, consideration should be given to how to recycle such waste. According to Iwamura (2005), the concept of recycling like this should not be planned only for specific projects, but should already be a social system integrated into the daily lives of most people.

Local issue: Harmony with the surrounding environment (high contact)

When the design concept addresses the potential views, the considerations should encompass not only the aesthetics but also its geographical conditions, climate, and the organisms inhabiting it. Ecological aspects within a building design should address the relationships among people, structures, and the overall environment. This aims to achieve a well-balanced human habitat. Therefore, as Iwamura (2005) says, when deciding on construction at a particular location, it's crucial to investigate environmental elements such as light, wind, water, soil, and living creatures. In other words, the development process must adapt to the history, landscape, and inhabitants of the surrounding area. By doing so, sustainability focus can also be extended to communities that align with the existing types of habitats.

Residential issue: A healthy residential environment with amenity (health & amenity)

According to Iwamura (2005), since the mid-1990s, the relationship between housing and the health of occupants has become a serious social issue. This is because, often unknowingly, the residential buildings people live in, consist of construction materials

containing hazardous chemicals that negatively impact air quality, especially in sealed indoor environments. Furthermore, due to the influence of the climate, these materials can foster the growth of mold and dust, posing risks to the health of the inhabitants. Hence, Iwamura (2005) suggests that in the design process, the concept of 'comfort' related to health needs should be re-evaluated against existing standards for light, temperature, ventilation, and humidity.

Parameters used in the sustainability analysis

Table 1: Parameters used in the research
Source: Iwamura, 2005

	Low Impact		High Contact	Health and Amenity
	Energy Saving	**Evective Use of Natural Resources**	**Compatibility and Harmony with the Local Environment**	**Health and Amenity – Be Safe and Feel Safe**
Parameter	1. Greater efficiency in reducing heat losses.	1. Structural and building methods for flexibility. 2. More durable skeleton. 3. Low emission.	1. Better harmony with the local ecological system and environment. 2. Greater consideration of townscape.	1. Through choice of safe and eco-materials.

Research Methodology

This research employs a qualitative descriptive research approach. Data related to the case study was obtained from literature studies and online references. Bajau tribe is a term used for seafaring communities in the eastern regions of Indonesia, such as Kalimantan, Sulawesi, and Maluku (Dwilla et al., 2019). This study focus more on the Bajau tribe in Sulawesi (see figure 2), although there is a possibility of data from the Bajau tribe on other islands to further enrich our understanding of how the Bajau people create dwellings to survive amidst the unpredictable natural conditions.

Fig. 1: The Distribution of Bajau Tribe Settlements in Bone
Source: Syarif et al., 2018

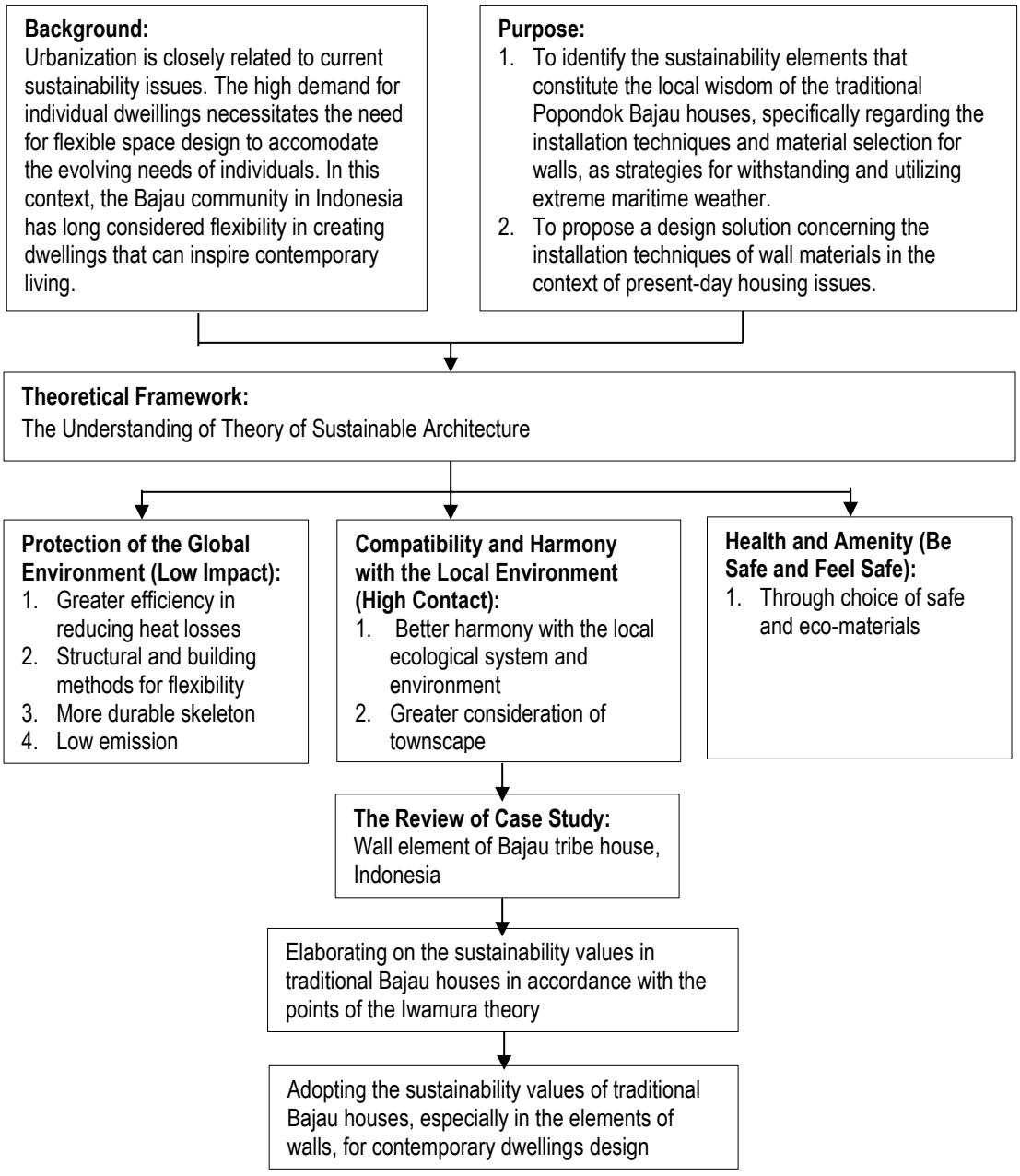
The Case Study

The case study is of the houses of the Bajau tribe on the water. The Bajau houses on the water still use assembly and disassembly techniques. These techniques are relevant to contemporary sustainability issues that emphasize spatial flexibility in creating comfort that can be controlled by the occupants. Data obtained from literature studies and internet searches include several aspects:

1. Transformation of Bajau dwellings.
2. Use of materials on walls.
3. The influence of climate on Bajau decisions in selecting materials.
4. Wall installation techniques employed by the Bajau.

Subsequently, analysis is conducted to identify the sustainability elements that constitute the local wisdom of the traditional Popondok Bajau houses, specifically regarding the installation techniques and material selection for walls, as strategies for withstanding and utilizing extreme maritime weather. It then proposes a design solution related to the installation techniques of wall materials in contemporary houses.

The steps of the research are as follows.



Findings and the Discussion

Background of the traditional Popondok House, the Bajau tribe, Indonesia

The captivating life of the Bajau tribe has gained international recognition with the release of the film 'Avatar: The Way of Water,' directed by James Cameron. In a surprising turn, Cameron explains that the inspiration for the depiction of the Metkayina tribe in The Way of Water, including their way of life, was drawn from one of Indonesia's indigenous tribes, the Bajau, who inhabit various aquatic regions of Sulawesi (Figure 2) (Arifa, 2022). This serves as evidence that foreign countries greatly appreciate the cultural richness and traditions possessed by Indonesia.

Fig. 2: The Inspiration for the Film 'Avatar: The Way of Water' originates from the Bajau tribe
Source: Arifa, 2022

In achieving a life that extends to the next generations, the Bajau tribe employs a process of trial and error in an effort to sustain their survival. This is evidenced by the transformation of dwelling forms carried out by the Bajau community (Table 2). Through the continuous evolution of dwelling forms, it can be said that the Bajau tribe is accustomed to the flexibility indicated by Iwamura's theory on the Global Issue: More Effective Use of Natural Resources. The process of changing the structure of traditional Bajau houses is based on two factors: the increasing size of family members and the growing addition of activities.

Table 2: The Transformation of Bajau Tribe Dwellings
Source: Salipu et al., 2022a, Dwilla et al., 2019

Numb..	The Transformation of Bajau Tribe Dwelling Forms		The Needs of The Bajau Tribe
1	Bidok		1.Initially, the community constructed boat-shaped houses as resting places due to their profession as fishermen. 2.There were also instances where two boats were lashed together to reduce the impact of sea waves.
2	Boboroh		1.Due to the need to process a significant quantity of sea produce, which required approximately 15 'bidok' (a traditional measurement) collected from their children, the 'boboroh' has been formed. 2.Over time, it has eventually been used as a residence for the 'ponggawe' (the elderly) after they ceased their voyages.
3	Popondok		1. As time passed, the Bajo community has then chosen to build houses above the water using wooden columns interconnected and non-permanent, making it easier to relocate to different areas. 2. Roof shape has changed to cover a larger space. 3. Orientation is towards the sea (dominant) and the land due to sanitary needs.

			4. Reinforcing the structure, transforming the roof ridge into a gable roof and using vertically arranged sagu palm fronds for the walls.
4	Rumak	 	1.Orientation toward the sea and the land 2.Due to the need for social interaction, dwellings were formed with an orientation towards the connecting bridge to the mainland. 3.A bigger space necessitates more pillars for support. 4.Some roof coverings are already made of zinc, indicating modernization.

Arrangement Techniques of Wall materials in a Bajau Tribe Dwelling as a Response to the Extreme Weather of Sea Waters

In material selection, the Bajau tribe actually possesses architectural insights into the local issue of harmony with the surrounding environment (Iwamura, 2005). This is evidenced by their choice of construction materials, predominantly wood, which allows for flexible replacement of building elements (Dwilla et al., 2019). They are conscious of the ever-changing aquatic environment due to waves, currents, winds, and tides; thus, they strive not to alter the existing phenomena but rather address the environment with a structure system that can be easily assembled and disassembled (Dwilla et al., 2019). In the Bajau architecture of Rampa Kampis Village in Kalimantan, the structural materials, such as columns and beams are made of ulin wood due to its resistance to sunlight exposure and seawater immersion for at least three years (Dwilla et al., 2019) (Figure 3). Once deteriorated, these wooden building materials are replaced with new ones (Dwilla et al., 2019).

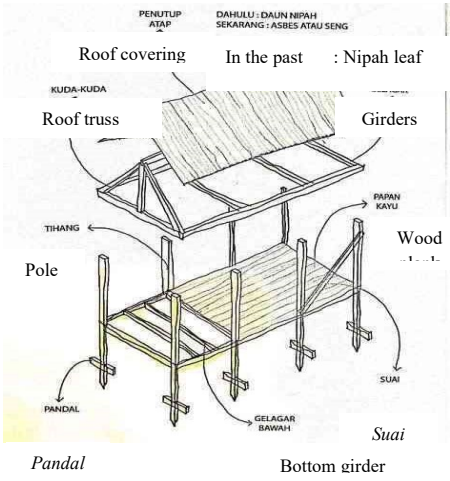


Fig. 3: The Structure of Traditional Bajau Tribe Houses Can Be Easily Assembled and Disassembled
Source: Dwilla dkk., 2019

The use of wall materials by the Bajau tribe community varies depending on their economic status. Apart from wood joined with nails, the Bajau people also utilize segments of nibung tree trunks with tied connections (Kusumo, 2022). The use of nibung tree trunks is due to their distinct characteristic of being straight with a strong, sturdy, and durable texture (Kusumo, 2022) (Figure 4). Nibung is a type of lowland plant that grows and reproduces in peat forests, swamp forests, and saline or coastal wetlands (Hardianty, 2018). The farther it is from saline water, the smaller the nibung population becomes. Coastal communities even believe that when submerged in water, nibung becomes stronger and more resilient (Fernando et al., 2020). Overall, nibung tree wood falls under the Class IV durability category (Fernando et al., 2020). Therefore, the Bajau tribe community, living in saline waters, harnesses the durability of nibung wood for use as wall material (Fajar, 2021).

Fig. 4: The Spiky Trunk with a Strong and Sturdy Texture of Nibung Tree Wood
Source: Fajar, 2021a

Influence of Climate on the Selection of Wall Materials for the Bajau Tribe

Selection of wall materials becomes paramount for the Bajau tribe community due to the challenges posed by the climatic conditions. The maximum air temperature in the Bone Regency reaches 33.80°C during the day and drops to 25.20°C at night (Juhana, 2020). The maximum air humidity in the morning and night can reach up to 94% (Juhana, 2020). Meanwhile, the daily air movement in the Bone Regency reaches 1.47 m/s (Juhana, 2020). According to SNI 03-6572-2001, the optimal comfort standards for people are within an air temperature range of 25.80°C to 27.10 °C, a relative humidity of 40% to 50%, and a cool wind speed of 0.25 m/s (Arifah et al., 2017). This proves that in the Bone Regency, during the daytime, the Bajau tribe community experiences very hot air with high humidity levels, while during the night, they experience very cold air with similarly high humidity levels. For the Bajau tribe members who still adhere to their local culture, utilize woven silar leaves or sagu palm fronds as wall materials (Syam, 2021) (Figure 5).

Fig. 5: Silar or Sagu Palm Fronds
Source: Mudita, 2012b

According to the Bajau community, using young silar leaves as house walls creates a cooler atmosphere compared to any other types of walls (Syam, 2021) (Figure 6).

Fig. 6: Woven Walls Made of Silar or Sagu Palm Fronds
Source: Syam, 2021

Apart from its ease of crafting, the reason behind their choice of silar leaf walls is its affordability compared to the other wall materials like boards (Syam, 2021). In fact, in the process of turning sagu palm fronds into wall material, several layers of fronds are glued together (Asriany et al., 2017). However, the thickness of the sagu palm frond wall material influences its compactness and water absorption capacity: thicker frond materials result in lower density and lower water absorption, while thinner fronds have a higher density and higher water absorption rate (Asriany et al., 2017). The durability of the Sagu palm fronds increases with lower moisture content (Asriany et al., 2017).

The choice of materials in the residential houses of the Bajau tribe varies. Some people have a medium economic level, and thus they use Nibung wood material (Kusumo, 2022). This is because wood has a small time lag when compared to bricks (Sukowiyono, 2011). Wood has a time lag of 0.60 hours while bricks have a time lag of 4.63 hours (Sukowiyono, 2011). On the one hand, wooden boards have a lower U-Value than bricks (Sukowiyono, 2011). They have a U-Value of 2.14 W/m2.K while bricks have a U-Value of 5.39 W/m2.K (Sukowiyono, 2011). This proves that during the day with hot weather in seawater, solar radiation rays can be easily received and re-emitted (Juhana, 2020). In fact, to reduce the amount of radiation entering the building, the walls used should have a large time lag with a fixed wall density that must be regulated so that they still have natural ventilation (Juhana, 2020). Therefore, the residential walls of the Bajau tribe should always be protected from direct sunlight (Juhana, 2020). On the one hand, with a low U-value, the wood plank wall material can act as a good insulator. That way, at night, the sun's heat can be stored in the room for a long time to warm the Bajau people against the cold temperatures in the sea waters.

Some Bajau people also use sagu palm fronds as wall materials (Syam, 2021). This is because sagu fronds grow in watery areas, and they are durable against moisture in the wet areas. They are easily accessible to the Bajau community in terms of location and cost. Sagu fronds that are dried and compacted can be a heat-absorbing material sufficient to reduce room temperature (Asriany et al., 2017). Those which have been processed into wall materials have a physical form similar to the wooden boards (Figure 7).

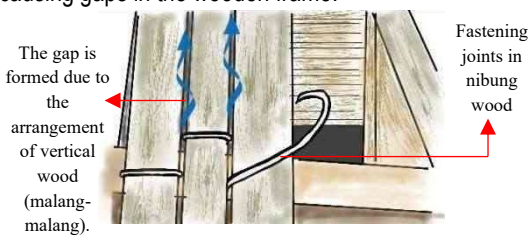
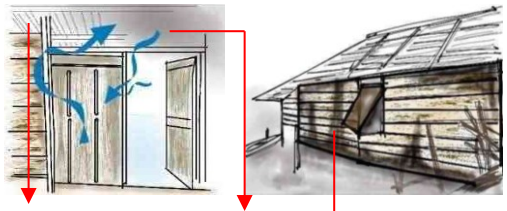
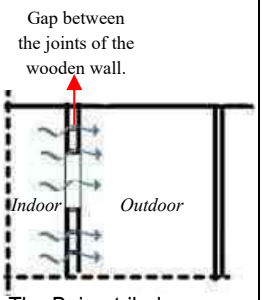
Fig. 7: Sagu fronds that have been processed into wall materials
Source: Asriany et al., 2017

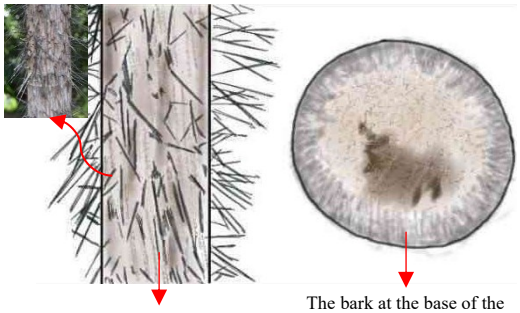
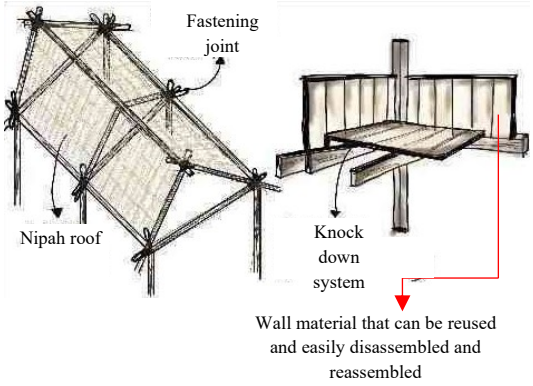
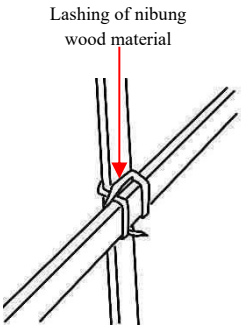
The drying process of sagu fronds takes more than one month until the moisture content is no more than 10% (Asriany et al., 2017). After drying, the sagu fronds are stacked in several layers and pressed to a certain thickness. In fact, the press results with a thickness of 2 mm can reduce the room temperature by 12.50°C (Asriany et al., 2017). However, the press results with a thickness of 3 mm can reduce the room temperature by 190°C (Asriany et al., 2017). The thermal ability of this sagu frond material is very suitable for use by the Bajau tribe during the day. This is because the site at sea consists of a wide expanse that does not have tree barriers or other tall buildings. That way, the sun's heat can directly hit the surface of the residential wall. Sagu frond wall material with a thickness of 2mm has a heat transfer rate of 0.0193 watt/m^0c, while sagu frond walls with a thickness of 3mm have a heat transfer rate of 0.0195 watt/m^0c (Asriany et al., 2017). The resulting value of the material is much smaller when compared to other materials such as bricks and glass walls. Bricks have a heat transfer rate of 0.0315 watts/m^0c, while glass walls have a heat transfer rate of 0.78 watts/m^0c (Asriany et al., 2017).

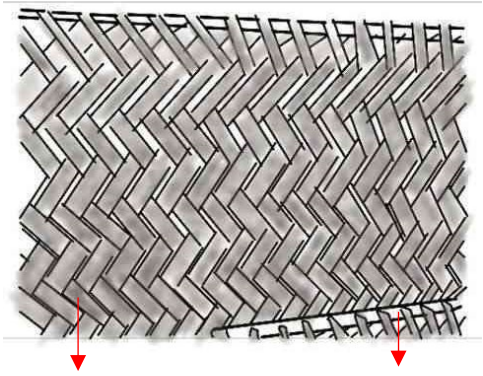
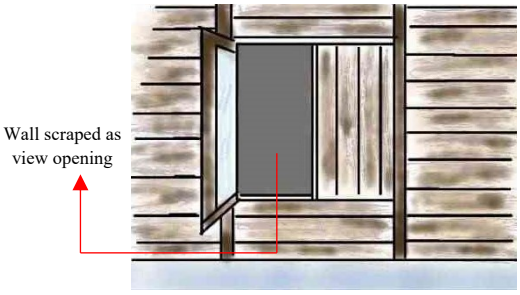
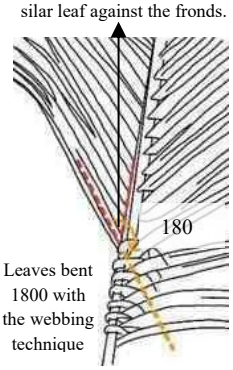
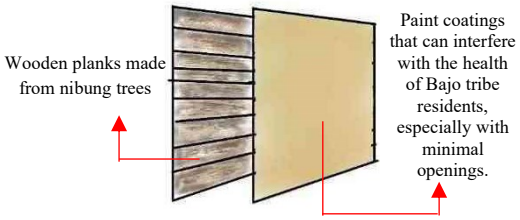
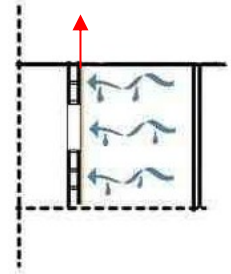
The method of installing sagu fronds into wall material is easy. Several sagu fronds are erected vertically and in a row (Hematang et al., 2021). After that, bamboo skewers are needed every 3–6 stems to glue the sagu fronds that have been arranged vertically (Hematang et al., 2021). The last step involves, the top and bottom of the sagu fronds, which are flanked by two pieces of wood to create a single unit of sagu frond wall construction (Hematang et al., 2021).

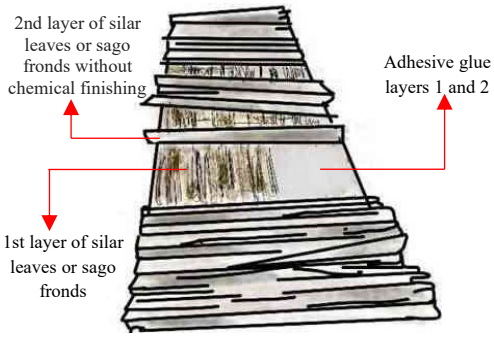
Effect of Wall Installation Techniques and Material Selection on Community Comfort

Table 3: Analysis of wall installation techniques and material selection
Source: Author, 2023

Number	Sustainability Aspects of the Theory	Analysis	Articulation of Local Wisdom
1.	***Global Issue (Low Impact)*** Issue: Extreme weather; trying to keep warm for the night while wanting air ventilation for stack effect and cross ventilation during hot days. • Energy Saving - Significant efficiency in reducing heat loss.	Quite effective. Utilizing vertical wood joining techniques (malang-malang) on Nibung tree wood wall material for air ventilation, promoting airflow circulation from outside to inside the building.  In traditional Bajau tribe houses that utilize class 2 wooden planks, the wooden plank joints on the wall are fastened with nails, which could result in gaps if one module of the highest wooden plank is removed, causing gaps in the wooden frame.  However, techniques like this often lead to wall damage, such as loosened joints between each other and susceptibility to leaks.  	 The Bajau tribal community stores solar heat energy at night through the density of Nibung wood plank materials on the walls and releases heat during the day through gaps in the lashing joints of the planks.

Number	Sustainability Aspects of the Theory	Analysis	Articulation of Local Wisdom
	• More Effective Use of Natural Resources - Durable framefork - Structural methods and construction for flexibility - Low emissions	Good. Using Nibung tree wood as the material for the walls of traditional Bajau tribe houses that are resilient against extreme weather conditions at sea.  Distinctive features of Nibung wood include a thorny stem with a strong and sturdy texture. The bark at the base of the Nibung tree has longer durability compared to other parts. This is because Nibung tree wood possesses certain characteristics: 1. Not easily rotted, even when submerged in brackish water. 2. Growing near the coast or areas close to water. 3. Commonly used as a building material in peatland areas. The wall material is related to the overall structural system, namely knockdown (disassembly and reassembly), which is rigid yet flexible, allowing the dismantled wall material to be reused. This is because the construction of housing for the Bajau community needs to adapt to uncertain extreme weather conditions and the direction of natural resource availability. Although it can be reused, the durability of wood has a limitation of around 3 years.  	 The Bajau community applies a prefabrication system through wall connections. The structural system adapt to the extreme weather conditions and the direction of available natural resources.

Number	Sustainability Aspects of the Theory	Analysis	Articulation of Local Wisdom
2.	***Local Issue (High Contact)*** • Compatibility and harmony with the local environment - Good harmony with the local ecological system and environment - Bigger consideration than cityscape	Good. In the Bajau community, which has a low economic level, people use wall materials made from woven sago palm leaves for the following reasons: 1. The material is easily obtained in marshes and coastal areas and is inexpensive. 2. It provides a cooler environment due to its lower density and reduced conductivity, which prevent the easy transfer of heat during the daytime. 3. From an aesthetic perspective, the technique of weaving sago palm leaves is more unique and representative of the traditional identity of the Bajau tribe.  The sago palm leaf weavings are arranged perpendicular to each other. The wall frame serves as the framework for weaving sago palm leaves. To appreciate the view of the deep blue sea, Bajau tribal houses with a seaward orientation always include apertures in the walls, which can be either windows or doors with a terrace.  Wall scraped as view opening	The angle is formed naturally by the slope of the silar leaf against the fronds.  180 Leaves bent 1800 with the webbing technique In choosing wall materials, the Bajau chose environmentally friendly materials with unique installation techniques and high aesthetics.
3.	***Residential Issue (Health & Amenity)*** • Be Safe and Feel Safe - Through choice of safe and eco-materials.	Good. The use of wood from the nibung tree has natural extractive substances that can increase the durability of the material. However, Bajo people often add more active chemical substances in the form of paint coatings with the aim of overcoming moisture that can destroy the material quickly.  Wooden planks made from nibung trees Paint coatings that can interfere with the health of Bajo tribe residents, especially with minimal openings.	Paint protects the board from the high humidity of the air around the sea.  In installing wall materials, some Bajau people do not pay

		In the processing of silar leaves or sago fronds into wall materials, only the active substance glue is used as an adhesive in layers 1 and 2. However, the glue is only located inside the material, while the outer side is left natural. 	attention to materials that are safe and comfortable. However, there are also some who have thought about the safety and health residents.

Application of Sustainability in the Installation Techniques and the Selection of Wall Materials in the Traditional Popondok House

The Bajau choose natural materials, such as nibung wood and silar leaves or sago fronds, because these materials can be installed as wall elements using a dismantling technique. This is one of their responses to the extreme climate, so that they can move at any time when the weather is bad. Various materials are also part of the utilization of natural resources around them, especially seawater. Therefore, the use of these materials can save construction costs, such as in terms of transporting raw materials from the production site. The process of installing the materials into wall elements is also done manually, using the skills of the people.

Application of materials does not require heavy equipment that causes carbon emissions. In terms of maintenance, the selected classifications of wood, silar leaves, or sago fronds have characteristics that are resistant to the salt content of the sea water and humidity in the water for a certain period of time. Thus, the use of these wall materials can also save on operational costs, such as the maintenance required to maintain the integrity of the wall material. Even if the durability period has expired at a certain time, the material only needs to be replaced with materials that can be taken from Nature at any time.

Indeed, not only that, the material can be reused for the construction of the next dwelling as long as the quality of the material has not reached the durability limit. Leftover construction materials can be used as boat or vessel building materials. This creates no construction waste. The Bajau go through a trial-and-error process to get the best wall material connection techniques, such as ikat joints, to adjust the temperature and humidity of the air as well as the movement of the surrounding wind for the comfort of their shelter. Thus, majority of the Bajau people still use natural materials rather than chemicals, both as coatings and adhesives. In terms of health, this adds to the comfort of the Bajau people who live in these traditional houses.

Proposed Design Employing the Installation Techniques and Selection of Wall Materials for Contemporary Housing: Inspiration from the Bajau Tribe

The flexible walling technique of the Bajau tribe inspires modern residences to implement demountable walls to accommodate the different personalities of each individual or family. This technique is one of the solutions to overcome space limitations amidst the lack of land availability due to urbanization. Inspired by the silar leaf weaving technique, a movable wall with a hexagon pattern is proposed (Figure 8).

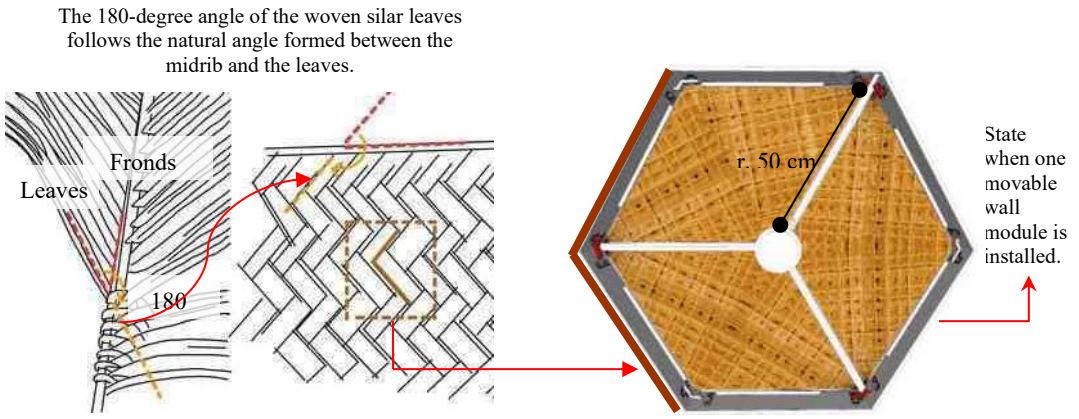


Fig. 8: The Angle of Woven Silar Leaves Inspires the Formation of Hexagons in the Movable Wall
Source: Author, 2023

This movable wall was designed employing Iwamura's 3G approach, namely:

Global Issue (structural and building methods for flexibility):

1. Movable walls utilize an assembly system for easy movement and portability.
2. Movable wall storage requires less space as it can be stacke

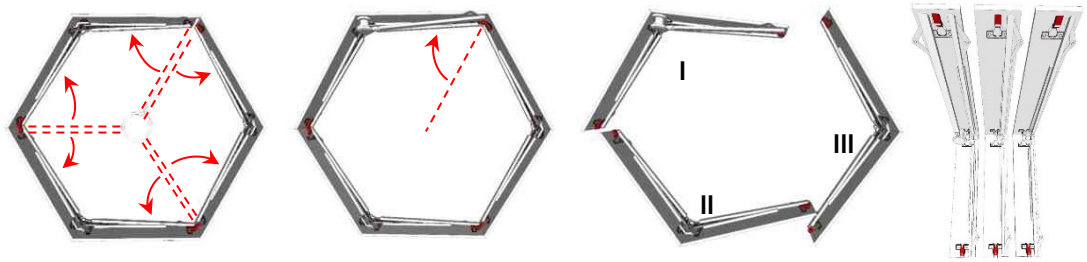
Local Issue (good harmony with the local ecological system and environment and with regard to scenery and aesthetics):

1. Movable walls using hinge connections, aluminum, and rattan imitation, which are easily available in this era.
2. Hexagon pattern on the movable wall to match aesthetics and the hinge system.

Residential Issue (safe and comfortable materials):

1. Movable wall finishing does not use paint.

There are 4 steps to disassemble the hexagon assembly into stackable parts to minimize the use of space for storage:



1. Remove the spring lock from the centre shaft. Then bend the folding rattan towards the rail base.
2. Bend the elbow hinge on the aluminium pipe (main shaft) into the frame.
3. Release the removable bent spoon full hinge at 3 points.
4. Stack the parts and store them in the warehouse.

Fig. 9: Steps to Disassemble the Hexagon Partition
Source: Author, 2023

One hexagon module can be assembled into a single partition. In addition to facilitating storage, this partition assembly is produced to maintain the privacy between people. One of the

advantages of the hexagonal partition is that it is not easy to disassemble, unlike the rolling door partition, which is easy to slide. The key to the hexagon installation technique is that the connection between modules must be rotated tightly vertically. If one wants to remove the hexagon modules, the occupants can rotate each module in the opposite direction. This is because a fischer or dyna bolt is installed between the hexagon modules, which functions as an adhesive (see figure 10).

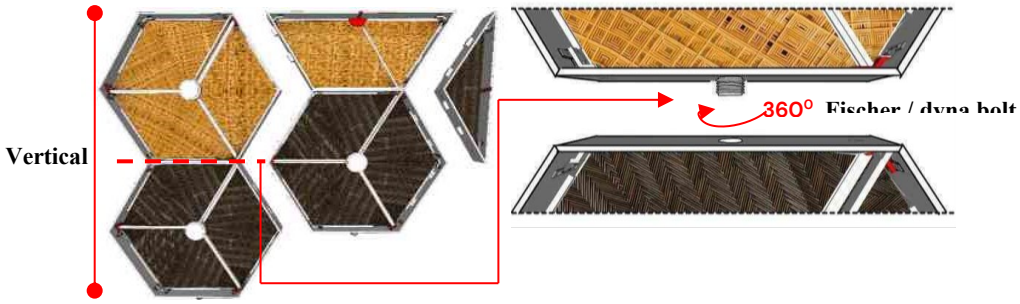


Fig. 10: The Module Installed Vertically First, Secured with Fischer or Dyna Bolt Connections
Source: Author, 2023

Horizontally, the hexagon modules just need to be connected like "legos" (see figure 11). Each module has two sides, namely the right side that has been punched and the left side is installed with aluminum hollow.

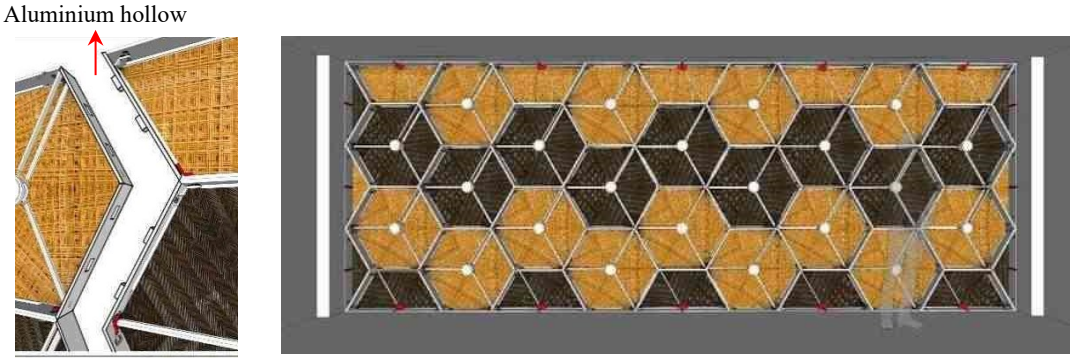


Fig. 11: Assembly of Hexagon Modules
Source: Author, 2023

The selection of movable wall materials uses materials that are easily available today, such as aluminum frames (10 cm x 1 cm), aluminum pipes that function as shafts, and rattan imitation, which functions as a filler sheet. Rattan imitation has advantages, such as easy cleaning, light weight, and utilizing unused plastic waste (Trisna & Utami, 2019). Movable walls only need to be placed between columns and beams (see figure 12).

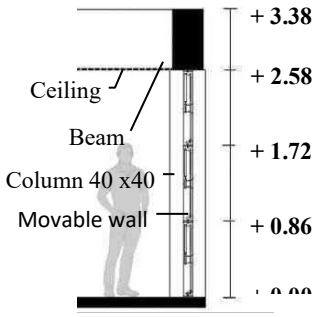


Fig. 12: Movable Wall Selection Against Columns and Beams
Source: Author, 2023

Conclusion

This paper generates many insights that can be drawn from the Bajau community for the production of sustainable housing today. They can be summed up as follows.

1. Utilization of natural materials that can respond to weather conditions and adjust the availability of natural resources in the house group on land.
2. Use of flexible wall material installation techniques.

The proposed movable wall design is one solution to maximize space utilization within contemporary land limitations that inspired by the Bajau way of life. Undeniably, there may be other ways in which these insights and lessons can be transferred and utilized in contemporary housing.

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