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Cultural Aspects as a Foundation for Sustainable Architecture: Lessons from Vernacular Practices

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Abstract

Ngadisari Village, located in the mountainous region of Mount Bromo, has characteristics of local wisdom in its settlement organization. The uniqueness lies in the religious context, including ancestral regulations and policies. The Tengger settlements exhibit distinct spatial patterns, especially in the placement of sacred sites (punden/pedanyangan) linked to their belief system. This research aims to identify the local wisdom of the settlements and the spatial patterns of settlements in Ngadisari Village. The data collection methods used in this research were literature studies, observation, and interviews, with a descriptive qualitative approach. The research results showed that the Tengger Tribe predominantly inhabits Ngadisari Village, and that the community's behavior is still governed by the Tengger Tribe's customs and laws. The Tengger people believe that Mount Bromo is the center of orientation and the axis of spiritual activities for the entire Tengger community. Ngadisari Village has a customary spatial formation that starts from the village cemetery, Pura Tunggal Jati, and Pura Brahmana. The institutional structure of Ngadisari Village is divided into roles and functions between the administrative and customary areas. In Ngadisari Village, there are two territorial divisions: the administrative area, led by the village head, and the customary area, led by the customary chief. The settlement patterns in Ngadisari Village are linear, scattered, and clustered. Trading areas dominate linear settlement patterns, while scattered settlement patterns represent traditional communities in the hillside areas. Meanwhile, clustered settlement patterns are seen among communities living around temples or sacred places of worship.

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1. Introduction

The escalating environmental degradation represents a critical challenge for the global community, with the building sector identified as a major contributor to this issue (Guy and Moore, 2004; Livi-Bacci, 2017; Windapo, 2014). Buildings account for a significant share of energy consumption and carbon emissions, underscoring the urgent need to address their environmental impact. In response, international initiatives such as Local Agenda 21, developed within the United Nations' Agenda 21 framework, emphasize the implementation of sustainable development strategies at the local level. Localized interventions are viewed as key to achieving sustainability outcomes due to their ability to address specific community needs and contexts (Gibbs et al., 1998; The International Council for Local Environmental Initiatives (ICLEI), 1996).

However, despite its potential, Local Agenda 21 has faced criticism for its occasional "one-size-fits-all" application, which often overlooks the unique cultural, social, and environmental contexts of different communities. This lack of adaptation can result in sustainability plans that fail to align with local realities, reducing their effectiveness and relevance (Sharp, 1999). Bridging the gap between global sustainability goals and local needs requires a responsive approach that considers the specific environmental and cultural conditions of each context. Universal strategies that neglect these nuances risk being counterproductive and may undermine the intended sustainability outcomes. Architecture that responds to local context provides significant sustainability benefits, not only for the environment but also for the surrounding communities. This responsiveness emphasizes the importance of understanding "locality" in qualitative rather than quantitative terms (Peters, 2015).

The concept of "place," defined by its distinctive economic, social, and physical characteristics, plays a central role in sustainable design (Massey and Jess, 1995). This idea is further enriched by the concept of *genius loci*, which captures the unique spirit of a place as shaped by its cultural and historical dimensions. *Genius loci* serve as a guiding principle in sustainable architecture, shaping how individuals and communities interact with and adapt to their environment in ways that honor its inherent potentials and limitations (Karaman, 2001; Norberg-Schulz, 1979; Vecco, 2020). By incorporating *genius loci*, sustainable architecture shifts from purely technical solutions to more human-centered approaches that respect sociocultural practices. This perspective fosters a deeper connection between design and the local community, ensuring that architectural solutions are both sustainable and contextually relevant. This research seeks to explore the critical aspects of sustainable architecture that must be addressed to reflect the *genius loci* of a place. Through a synthesis of existing literature, it aims to provide architects with insights and strategies for designing buildings that are environmentally sustainable, socially inclusive, and culturally meaningful. By prioritizing local context, this approach enhances the effectiveness and acceptance of sustainability initiatives, contributing to more impactful and resilient outcomes.

2. Cultural Sustainability in Architecture: The Role of Genius Loci and the Debate on Culture as a Pillar of Sustainability

The concept of genius loci refers to the unique characteristics that define a place, which include its historical, cultural and environmental context. This concept supports sustainable architecture to encourage context-sensitive design that aligns with local

identity and traditions. Sustainable architecture benefits from the fact that cultural sustainability can foster a sense of belonging, which is crucial for the sustainability of sustainability initiatives (Soini and Dessein, 2016). Understanding the dimensions of sustainability mainly revolves around 3 main dimensions: environmental, social and economic. These dimensions are important in addressing the ecological impacts of buildings, ensuring social equity and promoting economic viability. However, these three dimensions although fundamental, overlook an important aspect for the success of holistic sustainable architecture, namely culture. In recent years, culture has been increasingly identified as an important dimension to incorporate sustainable development (Cucco et al., 2023; Jahan, 2023; Lazar and Chithra, 2022; Wu et al., 2016). Cultural values are essential to sustainable development as they shape how a community interacts with the environment, influence social cohesion and drive economic activity (Jahan, 2023). Culture also significantly influences place characteristics especially in a person's experience with the environment, including their lifestyle. (Kopec, 2018; Rapoport, 1987; Winchip, 2011). This cultural influence extends to local behaviors, practices and overall sustainability strategies, illustrating that cultural backgrounds are strongly linked to how environmental challenges are faced.

The recognition of the cultural dimension as a pillar of sustainability highlights that culture integrates anthropological and socio-economic dimensions, making it essential for a holistic approach to sustainability. Recognizing and integrating this cultural dimension into sustainability frameworks is essential (Cucco et al., 2023; Jahan, 2023; Lazar and Chithra, 2022; Wu et al., 2016). This emerging paradigm shift recognizes that cultural values profoundly influence how communities interact with their environment, shaping their behaviors, practices, and ultimately, their approaches to sustainability (Jahan, 2023; Kopec, 2018; Rapoport, 1987; Winchip, 2011). UNESCO and international summits have supported this perspective and advocated for the integration of cultural considerations into sustainability frameworks (Prabowo and Salaj, 2023). Although increasingly recognized, cultural sustainability faces challenges related to definition and implementation. The implementation of cultural strategies needs strategic prioritization and practical application to ensure that culture is not overshadowed by economic, environmental and other priorities. (Duxbury and M. Sharon Jeannotte, 2013; Vikmane and Laķe, 2021). The integration of culture as the fourth dimension of sustainability shows that architecture is not only about the physical environment, but also about the socio-cultural conditions that exist in a place. Several studies show that culture is a dimension supporting sustainability, particularly in relation to the spectrum of human experiences and community needs in sustainable architecture (Pragyan Dash and Shetty, 2020; Soini and Birkeland, 2014; Wu et al., 2016). This shifts the discussion of sustainability from focusing on physical and ecological contexts to focusing on human experiences and cultural expressions, especially when including culture as one of the dimensions of sustainability as illustrated in Figure 1.

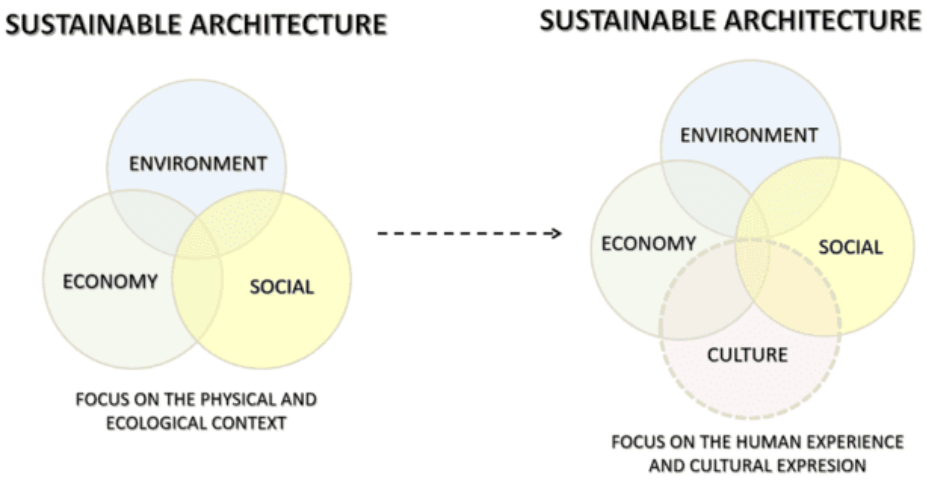

Figure 1. Shifting Focus of Sustainable Architecture
Source : Author, 2025

Culturally sensitive architecture is not only appropriate to its geographical location but to the fabric of the society it serves. The building is thus not an isolated object, but an integral part of the human experience and cultural expression. When ignored, this disconnect can lead to reduced engagement, less satisfaction or even rejection of sustainable practices, undermining the long-term success of the building (Horlings, 2015; Memmott and Keys, 2015; Pragyan Dash and Shetty, 2020). This approach ensures that the architecture is relevant and meaningful to the people using it which in turn fosters a strong connection between the user and the built environment.

3. Method

The research follows a structured and multi-stage approach that aims to identify gaps in sustainable architecture when considering genius loci. The methodology consists of four main stages: (1) a systematic literature review, (2) selection and analysis of case studies, (3) comparative evaluation, and (4) synthesis of findings and recommendations.

1. Stage 1: Systematic Literature Review
   The literature review for this study follows the "Preferred Reporting Items for Systematic Review Recommendations" (PRISMA) guidelines (Moher et al., 2009). The process was carefully executed through the following steps:
   a) Search strategy
      - A thorough search for relevant academic articles was conducted using the Publish or Perish tool, which retrieves papers from databases such as Scopus and Google Scholar to ensure a comprehensive collection of literature.
      - The search was guided by a well-defined syntax: '*local context*' *OR* '*contextual*' *OR* '*genius loci*' *AND* '*sustainable architecture*'. This syntax ensured precise retrieval of articles by targeting specific terms in the title, abstract, and keywords. The search focused on publications from 2014 to 2024, reflecting recent developments and research trends.
   b) Screening and review process

- The initial set of retrieved articles underwent a detailed screening and review process, adhering to methods used in similar systematic reviews (Khatibi et al., 2023; Kuru Yücel, 2023; Zhang et al., 2023).
- The collected article records were organized in Mendeley, and the screening was performed based on titles, keywords, and abstracts. Only peer-reviewed journal articles written in English that specifically discussed sustainable architecture in relation to local context or genius loci were included.

c) Analysis:
- A bibliometric analysis was conducted on the 88 selected articles using Vos Viewer. This analysis aimed to visually represent key trends and interrelationships in the literature through a co-occurrence map network.

d) Synthesizing key findings

Identify and summarize the most prominent themes or topics that emerged from the co-occurrence network visualization and point out any emerging trends or shifts in focus within the literature.

2. Stage 2: Selection and Analysis of Case Studies

In the second stage, case studies of vernacular architecture known for their strong expression of genius loci and sustainable practices were purposefully selected. Three case studies from diverse regions in Indonesia were chosen: a) Waerebo, Nusa Tenggara Timur, b) Kajang, Sulawesi Selatan, and c) Tenganan, Bali

The three traditional villages were selected because of their significance as mother villages, the initial centers of tribal dispersal in their respective regions. Their existence reflects cultural and social aspects and retains vernacular architectural forms that are an important legacy for the wider community. These three villages also have authentic architecture, less affected by modernization than their descendant villages. They are also a source of cultural identity, holding traditional architectural knowledge systems passed down from generation to generation in construction techniques, the use of local materials, and the relationship between space and the community's social patterns. In studying vernacular architecture and sustainability in three mother villages (Waerebo, Kajang, and Tenganan), data were collected through direct observation and interviews with tribal chiefs to understand each village's historical, spatial, and social aspects.

3. Stage 3: Comparative Evaluation

The third stage involved a comparative evaluation of the selected case studies to assess how the principles of genius loci have been adapted for sustainability. The analysis highlighted several key principles that could be adapted for modern sustainable design.

4. Stage 4: Synthesis of Findings and Recommendations

In the final stage, the study's findings were synthesized into a cohesive set of conclusions and actionable recommendations. The research underscores the importance of integrating genius loci into sustainable architectural practices and outlines principles that can guide future design efforts. By combining a systematic literature review with in-depth case study analysis, this research provides a holistic understanding of the intersection between genius loci and sustainable architecture.

4. Result and Discussion

Uncovering patterns of sustainable architecture and genius loci

The bibliometric analysis of the 88 selected articles resulted in a network visualization that provides valuable insights into how different concepts interrelate in the context of integrating local aspects to achieve sustainable architecture. This analysis enabled the identification of relationships among key concepts through a co-occurrence map, a visual representation of the research landscape. Each node in the network corresponds to a specific keyword, and the node's size reflects its frequency of occurrence in the reviewed literature. Connections between nodes are represented as lines, where thicker lines signify stronger co-occurrence between terms. The network further categorizes related terms into clusters, which are visually distinguished by color. These clusters group keywords by thematic similarity, providing a clearer understanding of the field's dominant topics. Additionally, the spatial proximity of nodes indicates the strength of their relationship, with closer nodes representing stronger conceptual links (Van Eck et al., 2010). Analyzing the co-occurrence network revealed patterns and thematic interconnections, highlighting the field's primary areas of focus and emerging trends. This approach not only provides a comprehensive overview of the research landscape but also uncovers significant gaps and potential opportunities for future exploration within sustainable architecture, particularly concerning the integration of local context and genius loci. Figure 2 illustrates the network visualization of key concepts derived from 88 selected articles, highlighting how discussions on local context are positioned within the broader discourse of sustainable architecture.

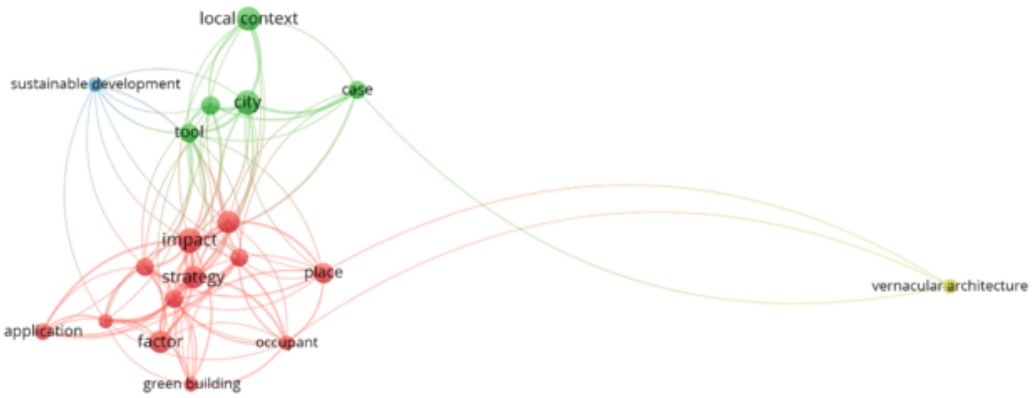

Figure 2. Network visualization of key concepts in sustainable architecture and local context
Source: Author, 2025

The network visualization illustrates the relationships between concepts, organized into four primary clusters. Each cluster is labeled to represent the central concept that connects the associated terms, as detailed in Table 1.

Table 1. Four main clusters in the network visualization

Cluster 1 (Red) Sustainability Strategies and Performance	*Cluster 2 (Green)* Context dependent sustainability	*Cluster 3 (Blue)* Global Sustainable Development Goals	*Cluster 4 (Yellow)* Culturally relevant architectural practices
Application	Local context	Sustainable development	Vernacular architecture
Green building	City		
Impact	Case		
Performance	Nature		
Place	tool		
Strategy			
Occupant			

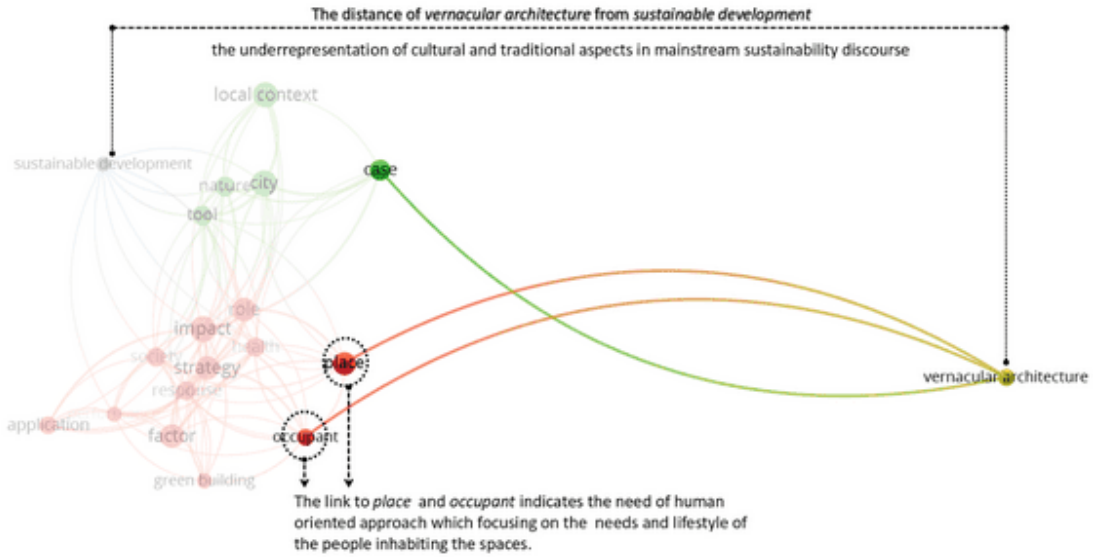

Figure 3. The underrepresentation of vernacular architecture in mainstream sustainability discourse
Source: Author, 2025

The yellow cluster, which focuses on vernacular architecture, is positioned farther from key concepts such as the global Sustainable Development Goals (blue cluster) and context-dependent themes (green cluster), as illustrated in Figure 3. However, it maintains connections with terms such as place, occupant, and case, reflecting its foundation in local context and cultural identity. The case link emphasizes the role of case studies in demonstrating the sustainability benefits of vernacular practices. Its distance from central sustainability concepts, as revealed by the network visualization, highlights a significant gap between vernacular architecture and sustainable development goals, indicating that cultural and traditional dimensions remain underrepresented in mainstream sustainability discourse. Mainstream sustainability focuses on environmental, social, and economic aspects but often neglects culture. Traditional practices, developed over centuries, play a vital role in sustainability by preserving ecological balance and social cohesion through the transmission of generational knowledge. Inspiration from vernacular architecture is important for expressing local identity and responding to global cultural homogenization. Vernacular architecture as a sustainable model has stood the test of time and reflects the cultural and environmental context of a region (Salman, 2019). This is becoming

increasingly important as modern views of sustainable architecture focus on technology, requiring a more inclusive approach that considers cultural and aesthetic dimensions (Grazuleviciute-Vileniske et al., 2021).

Local actors, including community members and artisans, are key to preserving vernacular architectural knowledge. Their lived experiences provide practical, culture-based solutions that support environmental sustainability. These local communities act as guardians of cultural heritage, preserving practices that are uniquely adapted to their specific ecological and social contexts (Duxbury and Jeannotte, 2012; Jeannotte and Duxbury, 2015; Wali et al., 2017). It ensures that sustainable practices are not only environmentally sound but also rooted in local cultural identity, thereby creating solutions that are truly holistic and resilient. Local initiatives that utilize local knowledge from local actors who play a role in community-engaged development foster a sense of ownership and responsibility among users that is critical to the success of long-term sustainability efforts (Mistry and Berardi, 2021; Pesch et al., 2019; Wang, 2020). The role of local knowledge is therefore crucial for culturally and environmentally relevant sustainability practices. The integration of local knowledge in sustainable architecture can reflect the unique cultural context of different communities. The contribution of local actors' knowledge to sustainability can be illustrated in Figure 4.

Figure 4. Local actor knowledge
Source: Author, 2025

By leveraging this localized expertise, sustainable architecture can move beyond generic, one-size-fits-all models to embrace strategies that are both environmentally resilient and culturally meaningful. This bottom-up approach ensures that sustainability is not just technologically driven but also socially embedded, fostering long-term environmental stewardship within communities.

Cultural wisdom in architecture: vernacular lessons for sustainability

Integrating cultural wisdom into architecture, particularly through vernacular studies, offers local insights that support sustainable practices. Sustainability in architecture cannot be separated from cultural values reflected in human life patterns and social and socio-economic factors that influence the development of a place (Lake and Jeraman, 2023; Neonbasu et al., 2024). *Waerebo, Kajang*, and *Tenganan* were selected to represent a distinctive synthesis of cultural values, environmental adaptation, and recognition in sustainable tourism. Waerebo's iconic *Mbaru Niang* houses have gained international attention as a UNESCO World Heritage Site. *Kajang* is notable for its strict customary laws that maintain low-impact living and cultural resilience, attracting both researchers and cultural tourists. *Tenganan*, one of Bali's most famous traditional villages, integrates ritual-based settlement patterns and the preservation of *geringsing* weaving, positioning it as a heritage tourism destination. Together, these cases highlight how vernacular wisdom sustains local life while creating contemporary value through tourism and ecological responsibility. This case study review of three study objects (Waerebo, Kajang, and *Tenganan* traditional village) explores vernacular architecture through local knowledge in four main areas: community lifestyles and values, collective memories and perceptions, local culture and construction techniques, and local resources, materials, and craft culture.

Community lifestyles and values

Vernacular architecture is strongly linked to the lifestyles and values of local communities. Emphasize that local knowledge, which is context-specific, shapes vernacular architecture to reflect the unique cultural and environmental conditions of a place (Hu et al., 2023). This architecture not only serves functional purposes but also embodies the community's identity and values, promoting sustainability through alignment with local practices and beliefs. The *Waerebo* Village in Manggarai Barat, NTT, has a U-shaped layout that reflects the living wisdom and deep cultural values of the Manggarai Barat people. U-shape represents the community's emphasis on togetherness, harmony, and inclusivity. The circular formation symbolizes the community gathering as one, with each house facing inward, creating a communal space in the center where people can gather for ceremonies and discussions. The house accommodates several families, typically 6 to 8, within a single structure. This communal living arrangement reinforces the bonds among family members, encouraging mutual support and cooperation. The communal kitchen is located in a central space for cooking and sharing meals, as illustrated in Figure 5. According to Yori Antar, this kitchen is not just a functional area but also a vital part of family life, where members come together to prepare food, share recipes, and engage. Moreover, the fog from the stove can maintain the building material (Antar, 2018)

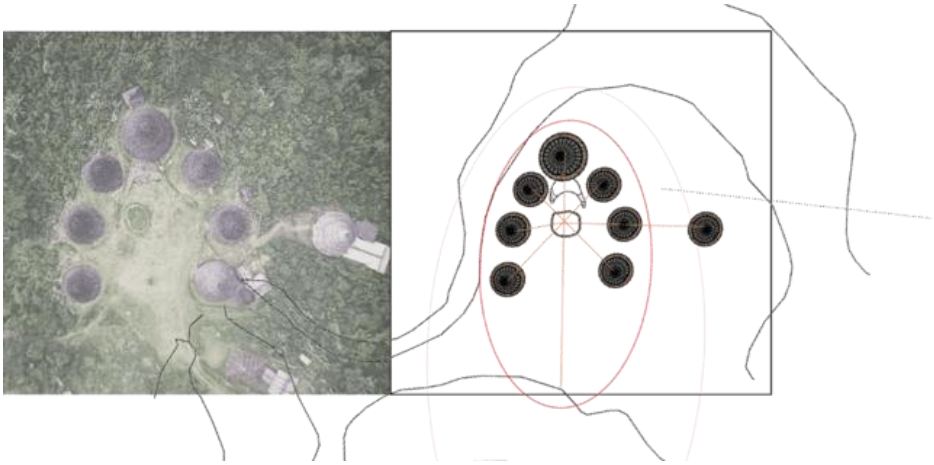

Figure 5. The *Mbaru Niang* Layout shows the communal spaces and kitchen
Source: Antar, 2018

Similarly, Chowdhooree and Das highlight how indigenous knowledge evolves from the experiences of previous generations, allowing communities to adapt their architectural practices to their environmental context (Chowdhooree and Das, 2022). The *Kajang* Tribe, located in Bulukumba Regency, South Sulawesi, resides in a sacred area called *Tana Toa*, which is considered their ancestral land and spiritual center. Their traditional houses, known as *Balla*, reflect a simple way of life and a philosophy of harmony with nature and society. The *Kajang* people adhere to a philosophy known as *Pasang Ri Kajang*, a set of ancestral values passed down through generations. Some core principles include b*alance with nature* that they take only what is needed and prohibit reckless tree-cutting, s*implicity* for rejected electricity, vehicles, and modern clothing (t*raditional clothing*, all residents wear black or dark blue garments, symbolizing equality and humility). The sacred forest, which only tribal elders are allowed to enter and from which they may gather resources, is a restricted area. In the *Kajang* context, the presence of such a sacred forest is illustrated in Figure 6.

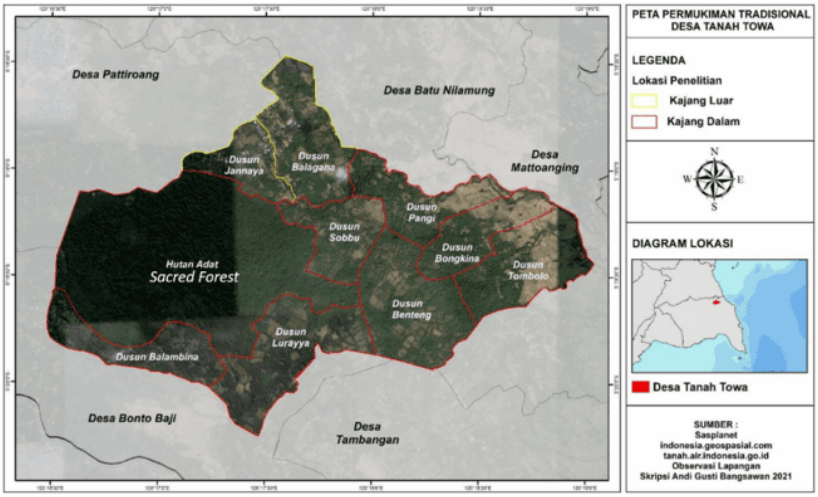

Figure 6. The Kajang area illustrates the presence of a sacred forest
Source: (Beddu, 2023)

The *Tenganan* Pegringsingan is one of the oldest *Bali Aga* (original Balinese Tribe) villages, located in Karangasem, Bali. A well-known cultural tradition in which young men engage in friendly ritual combat with thorny pandan leaves, symbolizing bravery and honouring the Hindu God Indra. Unlike other Balinese communities, it follows a distinctive communal system, where all families are considered equal, and land ownership is collectively managed, as illustrated in the site plan in Figure 7. To maintain their cultural identity, such as keeping the ancestral lineage intact and sacred social structures remain unchanged, the *Tenganan* people practice endogamy, meaning they marry within their own community. This village is known for its strict traditions, unique architecture, and deep connection to nature, particularly in the careful selection and preservation of resources for building construction. This adaptation is critical to maintaining cultural integrity while addressing contemporary sustainability challenges.

Figure 7. The *Tenganan Pegringsingan* traditional village site plan
Source : (Setiawan et al., 2020)

Collective memories and perceptions

Collective memories and perception play an important role in shaping vernacular architecture. This preservation is critical to maintaining people's collective memories, which inform their architectural practices and contribute to a sense of belonging. In addition, local wisdom, developed from historical experiences reflecting the people's collective identity. Such collective memories inform current practices and serve as a foundation for future sustainability efforts. The process of building an *Mbaru Niang* (Traditional house of Waerebo) begins with a sacred ritual to choose the right wood, ensuring durability and spiritual harmony. The selected wood must have specific characteristics; mature wood for ensuring strength and longevity, straight form for providing structural stability, and proper dimensions for ensuring the right proportions for construction. Building an *Mbaru Niang* is not just about construction; it is a community effort and a learning process. Elders and master builders *(tukang adat)* guide the construction process, the younger generations actively participate, observing and assisting in various stages to learn traditional techniques, as illustrated in figure 8. This hands-on experience encapsulate that the knowledge of materials, techniques, and rituals is passed down through generations, preserving *Wae Rebo's* architectural heritage.

Figure 8. Waerebo communal activity to build the *Mbaru Niang* house
Source: (Antar, 2018)

The *Kajang* Tribes follow a unique, spiritual process to elect their leader, known as the *Ammatoa*. The elders and spiritual leaders perform sacred rituals and signs from nature to confirm the right candidate. It is believed that the true *Ammatoa* is chosen by the ancestors and the spirits rather than by human decision alone. The *Ammatoa* serves as the spiritual and customary law enforcer, a mediator in conflicts and community decisions, also a guardian of the sacred forest (Ichwan, 2021). The election is followed by all types of Kajang Tribes: *Kajang Luar* (Outer *Kajang*) or *Kajang Dalam* (Inner *Kajang*). The Kajang Tribe is divided into two groups based on their relationship to modernization: Kajang Dalam (Inner Kajang), which strictly adheres to traditional customs and avoids modern influences. *Kajang Luar* (Outer *Kajang*), who live closer to the outside world and engage more with modern life. Despite their differences, the two groups maintain interaction, particularly through the traditional market, where they engage in a *barter system* to exchange goods. Activities of the *Kajang* tribe are illustrated in Figure 9.

Figure 9. The Kajang tribe's activities
Source: (Beddu, 2023)

In the village forest, the *Tenganan* people carefully select mature, *half-dried* wood for construction. It ensures the tree has already begun its natural decomposition, contributing to the forest's health by allowing younger trees to grow. According to their customs, the youngest child in the family is often entrusted with the responsibility of being the keeper of the traditional house (or *bale*). These case studies of vernacular architecture also show the balance and harmony between humans, as microcosm, and the environment or

universe, as macrocosm. There is a proposition that establishing a harmonious relationship between these two worlds is important, with the understanding that every activity at the microcosmic level will also involve the macrocosm.(Neonbasu et al., 2024; Salura and Holid, 2007)

Local construction cultures and techniques

The aerodynamic shape of the *Mbaru Niang* houses, with their cone-shaped roofs, plays a crucial role in protecting the occupants from strong winds (Pinassang, 2021). Unlike square or boxy structures, the conical form reduces air resistance by allowing wind to flow smoothly around the house, creating smaller separation zones (areas where airflow detaches from the surface). This streamlined shape results in narrower wakes (trailing vortices), minimizing turbulence behind the structure. Consequently, the cone shape is highly efficient in reducing the pressure and bending forces (or "moments") caused by wind, making the building more stable and resistant to wind excitation. This design is crucial for standing up to the wind-prone, mountainous environment in which *Mbaru Niang* houses are built. The enclosed structure with minimal openings keeps the indoor temperature stable, it is beneficial for residents, as it reduces the need for additional heating or cooling methods, making the design energy efficient and sustainable. Figure 10 illustrates the details of the *Mbaru Niang* form and materials.

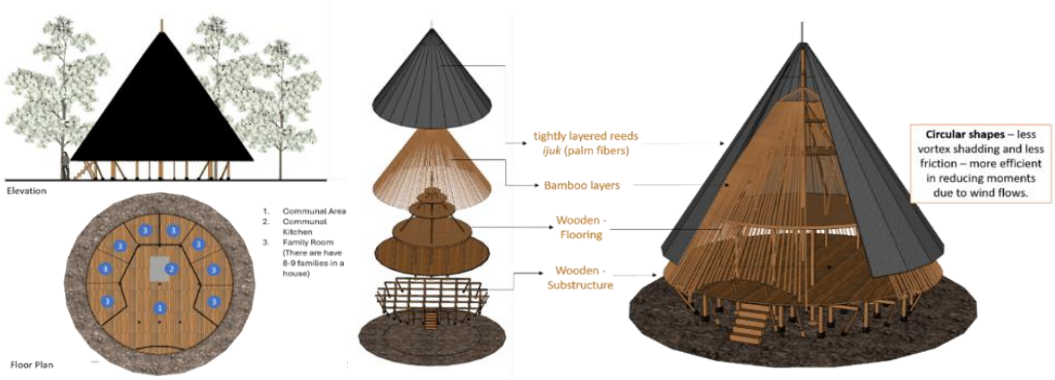

Figure 10. The *Mbaru Niang* form and materials
Source : Author, 2025

Kajang houses are built using natural materials such as wood and palm leaves for the roof. They employ traditional construction techniques without using iron nails, relying instead on wooden pegs. All houses face west, which is considered sacred in their beliefs. Key characteristics of their houses include stilted structure to protects against wild animals and ground moisture, the organics column, and minimal windows, and odd numbered steps for representing their life philosophy. Figure 11 illustrates the construction of the *Kajang* house.

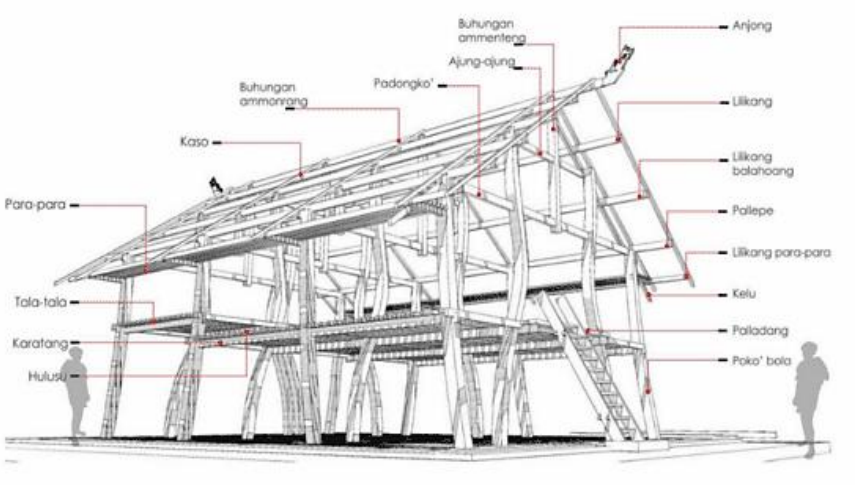

Figure 11. The *Kajang House* Construction
Source : (Beddu, 2023)

The people of *Tenganan* have maintained a deep respect for their environment, preserving its cultural identity and architectural heritage for centuries. *Tenganan's* traditional buildings use a *knock-down system*, meaning structures are assembled without permanent joints. This technique allows flexibility during earthquakes; buildings can be repaired or reassembled without significant environmental impact, and the system reduces waste and ensures resources can be reused over generations. *Tenganan* architecture is the *pointed* or *elevated* structural design; the construction does not fully seal the ground, allowing natural water infiltration. Figure 12 illustrates the construction of the *Tenganan* house.

Figure 12. The *Tenganan* house construction
Source: Author, 2025

Local resources, materials, and craft culture

Using local resources and materials is a hallmark of vernacular architecture, contributing to its sustainability. Traditional building materials and techniques are often

more environmentally friendly than modern alternatives, which rely on imported materials with a high carbon footprint (Pardo, 2023). The ecological aspects of local material manufacturing processes also illustrate how local materials and methods are integral to sustainable construction practices (Atmodiwirjo et al., 2018; Yatmo & Atmodiwirjo, 2021). This integration supports sustainability and fosters a new appreciation for traditional craftsmanship.

Waerebo resources, the local people carefully choose specific types of wood known for their strength and resilience against the elements, ensuring the longevity of the structure. Although the walls are made from woven bamboo and wood, they allow some air to pass through, further enhancing ventilation. The materials used ensure that the house "breathes," allowing for air exchange and helping to regulate temperature. The roof is made from dried reeds or palm fibre, and the thatch roof provides excellent climate insulation. *Waerebo* women are skilled in the art of *tenun*, a traditional handwoven textile craft passed down through generations. Most women in the village weave their own fabrics, creating intricate patterns using traditional *natural dyes derived from plants*. The colours, such as deep blues, earthy browns, and rich reds, are extracted from various natural sources. Figure 13 illustrates *tenun* handwoven craftsmanship.

Figure 13. The Waerebo *tenun* handwoven craftsmanship
Source: author, 2025

A unique tradition in the Kajang community is planting one tree per household. Every family ensures that for each house built, a tree is planted and nurtured, serving as a reserve for future generations. When children grow up and need to construct their own houses, they already have *mature wood* available, reducing the need for excessive deforestation. The sacred forest is strictly protected, and only tribal elders or designated community members are allowed to enter. The materials taken from the sacred forest, such as additional wood, bamboo, and palm leaves, are used only for essential construction. The *Kajang* house's wooden material is illustrated in Figure 14.

Figure 14. The Kajang House's wooden materials

Source : (Beddu, 2023)

Tenganan Village also uses identical wood for its buildings, especially for Bale, the secret village forest, which produces it. *Coconut Wood & Jackfruit Wood* are the most commonly used materials for constructing Bale houses, traditional houses, and public pavilions, due to their durability and resistance to tropical weather. *Gaharu (Agarwood) & Cempaka Wood*, these rare and precious woods are reserved for sacred buildings, temples, and offerings to the gods. It is known for its *fragrant aroma* and is often used in spiritual ceremonies and rituals. The village is famous for *Tenun Gringsing*, a rare and sacred *double-ikat woven fabric* believed to offer spiritual protection. The dyes are made from *natural ingredients*, maintaining sustainable craftsmanship.

Figure 15. The *Tenun Gringsing* as sustainable craftsmanship
Source: (Sukawati, 2020)

From the three case studies discussed above, several key cultural values in vernacular architecture can be identified as inspiration for addressing contemporary environmental challenges. The point in the cultural values of traditional houses is their symbolism of harmony between the surrounding conditions and spiritual thinking, respect for nature, and the continuity of ancestral traditions, which shape how the community uses the house, mainly as a place of rest rather than daily activity. As outlined in Table 2, these values are translated into lessons of vernacular architecture, such as communal resource sharing, spiritual ties with the natural environment, climate-responsive design, sustainable material cycles, and the preservation of local knowledge, all of which provide significant environmental benefits. Similar thoughts are highlighted in vernacular architecture research, where cultural dimensions are shown to shape building traditions (Abdel-Azim and Osman, 2018)Climate-responsive strategies demonstrate how traditional houses adapt effectively to local conditions. By prioritizing renewable and low-carbon material resources such as bamboo, timber, or adobe, vernacular architecture sustains a cycle of use that supports both ecological balance and the preservation of local identity (Khalil and Üzümcüoğlu, 2025). In this sense, material practice becomes more than a technical solution; it is also a cultural statement that ties communities to their environment and reinforces intergenerational knowledge.

Table 2. Cultural values in vernacular architecture for environmental benefits.

No	Key Cultural Values	Lessons from Vernacular Architecture	Environmental Benefits
1	Communal living and resource sharing	The collective use of shared spaces fosters social interaction, promotes resource efficiency, and minimizes material overuse	Encourages sustainable land use and reduces excessive consumption
2	Spiritual relationship of the community (as the microcosmos) with nature (as the macrocosmos)	Building rituals reflect the community's deep connection with nature as part of the wider universe (macrocosm), embodying wisdom in material selection to ensure both sustainability and durability.	Minimizes overexploitation of natural resources and fosters long-term environmental stewardship
3	Climate-responsive architectural forms	Roof forms are designed for the climate, while stilt structures help reduce humidity. Breathable walls and floors enhance ventilation, and minimal openings regulate temperature and improve environmental protection	Enhanced building resilience through climate-responsive design strategies and reduced energy consumption.
4	Sustainable material resources and the cycle	Strict regulations on timber use, such as selecting only mature logs to allow younger trees to thrive and implementing tree-planting practices for future generations, are essential for maintaining ecological balance and ensuring long-term material sustainability	Prevents deforestation, promotes biodiversity, and ensures long-term material availability.
5	Transfer of local knowledge and craftsmanship skills	The transfer of construction skills, material knowledge, and craftsmanship to the next generation ensures both cultural continuity and sustainability. However, as this knowledge has traditionally been passed down orally, proper documentation is essential to preserve and safeguard it for future generations.	Maintains cultural heritage while promoting sustainable building practices.
6	Minimal environmental impact & adaptive design	Utilizing locally sourced materials, minimizing deforestation, and implementing knock-down construction techniques contribute to environmentally sustainable buildings that reduce ecological impact and promote resource efficiency	Reduces carbon footprint, strengthens local economies, and enhances adaptability to environmental conditions with greater efficiency.

5. Conclusion

The evolution of architecture is inevitable, reflecting changes in technology, lifestyle, and economic demands. However, this evolution should not ignore the lessons embedded in history and local knowledge. Modern sustainability efforts can benefit significantly from the time-tested resilience, efficiency, and cultural depth of vernacular architecture.

The local knowledge contained in vernacular architecture results from a time-tested process of human adaptation to the environment. The sustainability of vernacular architecture lies in its physical form and the ecological ideas and principles behind the form. Therefore, in addressing today's environmental challenges, it is important not only to copy or imitate the physical form of vernacular architecture, but first to understand its reason for existence, i.e., how a form emerged from the functional, social, and ecological needs of the local community. An in-depth understanding of local values, benefits, and contexts in vernacular architecture can provide a foundation for developing more sustainable, context-specific architectural strategies.

The cultural lessons of *Mbaru Niang, Kajang*, and *Tenganan* vernacular architecture are expressed in communal life, ancestral continuity, and collective memory. *Mbaru Niang's* conical house design symbolizes harmony with nature. However, it limits daylight and expansion. *Kajang's* column system reflects resilience and tradition yet restricts adaptation, and *Tenganan's* ritualized planning sustains identity but reduces functional flexibility. All three rely on local resources and craft culture, which support ecological balance but are under pressure from scarcity and declining skills. These cases show that vernacular traditions offer valuable lessons, though their relevance today depends on critical reinterpretation rather than direct replication.

Thus, vernacular architecture principles can be adaptively applied to contemporary architectural design. By incorporating vernacular principles such as climate adaptability, community-driven construction, local material sourcing, and ecological harmony into contemporary design, we can create architecture that is not only functional and energy-efficient but also culturally enriching and socially inclusive. The challenge for modern architects, planners, and policymakers is crucial. Their role is to bridge traditional wisdom with technological advances, ensuring that sustainability is not just a technical solution but also a deeply rooted cultural practice, and the sustainability of modern architecture depends on their ability to integrate the wisdom of the past with the innovations of the future, with a more *human-centered* and environmentally conscious design approach.

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