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Sustainable Values in the Structure of Traditional *Osing* Houses in Indonesia

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Abstract: The worldwide energy crisis is causing people in most countries to reduce their energy use to prevent the next generation from being unable to fulfill their needs. The *Osing* people use sustainability values based on traditions passed down from generation to generation with appropriate technology to fit the needs of the people and their environment. This research employs a qualitative descriptive method with a literature review and data collection. Based on the framework used by Iwanmura, *Osing* house construction primarily focuses on the principles of low impact and health and amenity. This study reveals that the architectural design and construction process of an energy-efficient traditional building can be adapted to contemporary sustainable housing. The primary aim was to identify and analyze sustainability values in the construction process and techniques of traditional *Osing* houses in *Kemiren* Village, Banyuwangi, which can serve as a reference for modern sustainable architecture practices. The study reveals the uniqueness of traditional *Osing* construction using the local material *Bendo* wood, which can be dismantled from the foundation up to the roof joint systems, thus allowing the materials to be repaired and recycled down to the smallest parts and minimizing construction waste. The advantage of this building construction process is the use of traditional housing techniques to minimize the need for mechanical systems. This traditional construction method, using wood as the building material and considering climatic features, demonstrates how to achieve sustainable building values throughout all elements of a building that provides users with comfort and safety.

Keywords: sustainable architecture; *Osing* house; structure

Academic Editor: Avi Friedman

Received: 28 September 2024
Revised: 24 April 2025
Accepted: 26 April 2025
Published: 29 April 2025

Citation: Puspita, C.; Hariyanto, A.D.; Arifin, L.S. Sustainable Values in the Structure of Traditional *Osing* Houses in Indonesia. *Architecture* **2025**, *5*, 31. https://doi.org/10.3390/architecture5020031

1. Introduction

Indonesia has a high level of energy consumption, and energy is a major necessity in human life [1]. However, the availability of non-renewable energy is not proportional to the increasing energy demand, causing an energy crisis [2]. In this context, sustainable architecture is increasingly necessary. The architecture of traditional houses shows that despite limited knowledge, traditional values have long considered sustainability. Traditional Japanese architecture has a close relationship with traditional values and nature to create harmony, whereby traditional values become the basis for creating sustainability values [3]. The relationship between sustainability and traditional values stems from the response to the site context [4].

Previous studies have shown that traditional Japanese architecture incorporates sustainability through cultural values that emphasize harmony with the natural environment. The process of making traditional houses prioritizes the preservation of nature and achieves

social and economic justice [5]. Similarly, many traditional houses, including those in Indonesia, were built with strong attention to site context, the use of local materials, and social practices that support sustainability. Sustainable architecture occurs when there is a balance between the environment, economy, and society, thus showing that many traditional houses have adapted over time.

Although there are several traditional practices that hold sustainability values, the literature on how these values are implemented in traditional houses in Indonesia is still limited. One example of a traditional house enriched with traditional values is that of the *Osing* tribe. The traditional *Osing* house has gradually adapted to environmental changes, including climate variations, allowing it to develop sustainable values through its resilient construction and design [6]. This can be seen from the use of materials that are environmentally friendly and located around the village. The design considers the local climate so the house can adapt to local natural conditions, allows for the efficient use of energy, and maximizes renewable energy in the house. The *Osing* house represents the existence of cultural values and demonstrates how people interact with nature and adapt to the development of social life, and develop building resilience to climate change occurring over time [7]. In this study, *Osing* houses are categorized as both traditional and vernacular architecture: traditional due to their cultural and historical values passed down through generations [8], and vernacular because of their responsiveness to the local environment and climatic conditions [9]. This dual perspective facilitates a more holistic analysis of its sustainable values.

Osing houses display a balance between local values and sustainability. As a traditional type of house steeped in local values, traditional *Osing* houses demonstrate the use of local materials and distinctive construction techniques. The use of materials, consideration of the tropical climate, and consideration of the value of sustainability are the reasons for selecting them as the subject of this study. In addition, the efforts made by the community to maintain the formation of the *Osing* house is an interesting aspect to study. Some of the local materials used in construction are wood and bamboo, thus allowing the *Osing* house to be dismantled [10]. One of the elements analyzed in this study is the structural system of the *Osing* house, wherein the selection of structural elements forms a knock-down system that allows the building to be disassembled according to the needs of its users. Since ancient times, people have been indirectly made aware of the three key aspects of sustainability in the process constructing traditional houses such that they can achieve comfort and continue to survive. The purpose of this study was therefore to determine the value of sustainability in the architecture of traditional *Osing* houses.

2. Materials

2.1. Literature Research

Literature Review Methodology

This study adopted an integrative literature review approach as a method of identifying and examining sustainability principles relevant to traditional architecture, particularly the traditional *Osing* house. This approach enabled the integration of both theoretical concepts and empirical research findings. The goal of this study was to identify sustainability theories suitable for analyzing the traditional *Osing* house.

Based on an existing framework [11], the integrative review process in this study consisted of the following five stages:

1. Formulating the Guiding Question

This research is guided by the following question: "What sustainability theories are relevant to traditional *Osing* houses, and how can these principles be implemented in contemporary vertical buildings?"

2. Literature Search

The literature search was conducted through databases such as Google Scholar, Scopus, and ScienceDirect using keywords such as "Osing Traditional House", "Sustainable structure of traditional houses", "Iwamura Sustainability", and "Sassi Sustainable Theory". The inclusion criteria were (1) thematically relevant studies, (2) academic publication within the last 10 years, and (3) access to the full text of articles. Studies with a non-architectural focus or lacking contextual relevance to Indonesia were excluded.

3. Data Collection

The selected literature was analyzed using the Critical Appraisal Skills Programme (CASP, 2014) to assess its methodological quality and content relevance. The evaluation covered aspects such as validity, relevance, and theoretical contribution, as shown in Table 1.

Table 1. Critical Appraisal of Selected Literature Using CASP Checklist.

CASP Checklist	Arsitektur Berkelanjutan, Belajar Dari Kearifan Arsitektur Nusantara	Eksplorasi Konsep Keberlanjutan Pada Arsitektur Uma Fafoe di Kabupaten Malaka, NTT	Comparative Understanding of Traditional Architecture Based on Literature Review: Refining the Definition of Traditional Architecture	The Thermal Performance of Osing Houses in The Banyuwangi as Humid Tropical References	Konsep Arsitektur Rumah Adat Suku Osing di Desa Kemiren, Banyuwangi
Was there a clear statement of the aims of the research?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell
Is a qualitative methodology appropriate?	Yes No ✓ Cannot Tell	Yes No ✓ Cannot Tell	Yes ✓ No Cannot Tell	Yes No Cannot Tell ✓	Yes ✓ No Cannot Tell
Was the research design appropriate to address the aims of the research?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell
Was the recruitment strategy appropriate to the aims of the research?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell
Was the data collected in a way that addressed the research issue?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell
Has the relationship between researcher and participants been adequately considered?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes No Cannot Tell ✓	Yes No Cannot Tell ✓	Yes ✓ No Cannot Tell
Have ethical issues been taken into consideration?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell
Was the data analysis sufficiently rigorous?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell
Is there a clear statement of findings	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell
How valuable is the research?	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell	Yes ✓ No Cannot Tell

4. Critical Analysis of Selected Studies

Five selected journals were critically appraised using the Critical Appraisal Skills Programme (CASP) to assess their methodological quality and thematic relevance. These articles were chosen due to their direct connection to traditional architecture and sustainability, as well as their varied focus ranging from conceptual discussions to empirical case studies. The use of CASP ensured that only studies of sufficient academic rigor and relevance were incorporated into the analysis. Based on thematic analysis, the reviewed literature was categorized into three main groups. The first group includes studies that

discuss sustainability from a cultural and theoretical perspective, highlighting traditional wisdom and design philosophy (e.g., Articles 1 and 3). The second group focuses on construction practices and material use in traditional architecture, with detailed observations of vernacular building techniques (e.g., Articles 2 and 5). The third group examines the environmental performance of traditional structures, particularly thermal comfort and natural ventilation in tropical climates (e.g., Article 4). This thematic grouping supports a multidimensional understanding of sustainability in *Osing* houses.

5. Discussion of Results

Based on thematic classification, the selected journals were grouped into three categories: (1) conceptual and theoretical foundations of sustainability in traditional houses, (2) construction techniques and material implementation, and (3) the environmental performance of traditional building structures. These groupings were then used as the foundation for this research. Some studies reinforced the conceptual understanding of sustainability in traditional architecture, and others provided empirical insights into construction practices and the use of local materials, while a third group demonstrated the impact of environmental factors on structural design.

This thematic division aligns with the core focus of this study, which posits that the structure of traditional *Osing* houses inherently contains sustainability values. The findings of this review directly influenced the selection of sustainability parameters applied in the analysis.

The Iwamura framework was selected because it addresses the three fundamental dimensions of sustainability, i.e., environmental, social, and human health, all of which are implicitly and explicitly present in the construction logic of *Osing* houses. As a complementary comparison, the Sassi framework was also utilized, as it offers a more technical and structured approach. Sassi's parameters enable a more concrete evaluation of tangible elements such as energy efficiency, material use, and site adaptation.

Together, these two frameworks provide a holistic lens through which the sustainability values of the *Osing* house structure can be interpreted and analyzed, both conceptually and practically.

Sustainable architecture seeks to meet the needs of users in the present without jeopardizing the ability of future generations to meet their needs as well [12]. Sustainable design will have a positive impact on the environment, especially the surrounding nature. Sustainable architecture relates to creating and responsibly maintaining a healthy environment by considering energy use and environmental demands without overexploiting the environment [13].

There are two main objectives of sustainable architecture, namely the building must be able to minimize the impact that may be caused to the environment, and the building must be able to have an impact on the environment by meeting the needs of its users and improving the quality of the environment [14]. According to Sassi, there are several principles that must be implemented in the design process to achieve sustainability. Some of these principles are site and land use, community, health and well-being, materials, energy, and nature.

1. Site and Land Use
    a. Site selection to avoid environmental damage.
    b. Optimize land use and minimize development impact [15].
2. Community
    a. Involve users in the design process.
    b. Recognize social life and basic needs of users.
    c. Enhance user quality of life and promote sustainability education [15].

3. Health and Well-being
    a. Use non-toxic, healthy materials.
    b. Provide green spaces for walking, cycling, and relaxation.
    c. Ensure environmental benefits alongside user well-being [15].
4. Material
    a. Use local materials to reduce transportation pollution.
    b. Minimize material waste and encourage recycling [15].
5. Energy
    a. Transition to renewable energy sources.
    b. Optimize energy efficiency and reduce carbon emissions [15].
6. Water
    a. Reduce and streamline water usage.
    b. Effectively manage black, gray, and rainwater to prevent pollution [15].

Over the past 30 years, the understanding of materials and their characteristics has grown to recognize the impacts associated with materials from manufacture to construction, which affect people and the environment. Materials, energy, and water are the three main resources required to construct and operate buildings. These three resources are closely linked to how a building design can contribute sustainable value, particularly regarding resource scarcity and its environmental and social impacts.

As Sassi said, the sourcing of materials, their manufacturing processes, transportation requirements, final use, and disposal can involve extensive environmental and social damage, including global warming, pollution, depletion of natural resources, destruction of natural habitats, extinction of plant and animal species, waste production, destruction of communities, and health problems (2006:144).

Materials in sustainable architecture are commonly categorized into renewable and non-renewable resources. Renewable materials—such as wood, rattan, and bamboo—are valued for their relatively short regeneration cycles and lower environmental impact compared to non-renewable materials like stone or metal ores. The traditional *Osing* house predominantly uses wood, a renewable material, which aligns with sustainability principles by minimizing long-term environmental degradation. While renewable materials still require processing, their availability and regenerative nature make them more environmentally responsible choices in traditional construction [16].

The production of new materials is inevitably associated with environmental and social impacts. To minimize the need for new materials, it is important to make the most of existing materials. Furthermore, utilizing existing materials, which would otherwise end up in the waste stream, will reduce the impacts associated with waste disposal. Material maintenance also requires energy and is associated with the same impacts as building construction, albeit on a smaller scale [17]. Therefore, considering maintenance requirements in relation to durability and longevity helps reduce the impact of materials on service life. Materials can also affect building users in terms of comfort and health.

To reduce our impact, it is important to consider what makes it possible to reuse or recycle a building or component. To reuse a building or component, it must be in good condition, but that is not enough. If we examine buildings that have been in use for hundreds of years, we will find that they meet existing needs, fit into the urban or rural landscape, are often favored by the community, and are also often of good quality [18]. The three main opportunities to utilize existing materials are reusing existing buildings, reusing building components, and using recycled materials.

In designing for reuse and recycling, it is important to consider the service life and replacement frequency of building components and detail those that tend to be replaced

more quickly than others, enabling their removal without affecting the rest of the building. Components are often removed from buildings while still in good working order and can be reused provided they are not damaged during their removal. The use of simple fixings and durable materials helps to increase the ability of building components to be installed and dismantled multiple times [15]. Sassi's principle does not address the development process, so this article also looks at the principles of Iwamura.

Through the Environmentally Symbiotic Housing program, Iwamura highlighted three principles in sustainable architecture: low impact, high contact, and health and amenity.

1. Global Issue (*Low Impact*): This principle emphasizes the protection of the environment, governing the use of energy, conservation of resources, and minimization of waste production from various construction activities. Some of the parameters implemented are energy saving and efficiency, the effective use of natural resources, the efficient use of resources, and waste reduction [19].
2. Harmony with the surrounding environment (*High Contact*): This relates to climate, geography, and organisms that have habitats in the environment. Elements in the environment such as light, wind, water, soil, and organisms need to be researched toward applying their findings for development. In addition, harmony must be created between the local community and culture [19].
3. Health and comfort of the living environment (Health and Amenity): This theme focuses on the relationship between buildings and health, as the choice of materials, construction methods, ventilation systems, and other elements can potentially cause health problems in humans and other organisms. A related issue to health is comfort, wherein lighting, temperature, humidity, and ventilation are issues that need to be reanalyzed because they affect the health of users [19]. Iwamura discusses the building and the impact on its surroundings, and then investigates the function of the building.

The selection of sustainability criteria in this study was based on the framework developed by Iwamura, the parameters of which are integrated within the context of sustainable architecture, covering energy efficiency, the use of environmentally friendly materials, and user health. These three parameters reflect the key dimensions of sustainability: environmental, social, and economic.

Meanwhile, Sassi outlines sustainability principles that include site use, material selection, energy, and community. Conceptually, there are similarities between Sassi's and Iwamura's frameworks (Table 2). However, Iwamura's framework is considered more comprehensive, as it includes the essential parameters found in Sassi's theory while presenting them in a more holistic and adaptable format, especially when applied to local contexts. For these reasons, Iwamura's parameters were chosen to analyze the sustainability values embedded in the structural elements of traditional *Osing* houses.

Table 2. Relevance between Iwamura's and Sassi's sustainability frameworks.

Sassi's Principles	Iwamura's Parameters	Description of Relevance
Site and Land Use	Low Impact	Reduces ecological footprint and ensures minimal environmental disruption.
Material		Encourages efficient use of material and waste reduction.
Energy		Reduces negative global impacts through responsible energy use.
Water		Minimizes environmental pollution and preserves natural ecosystems.

Table 2. *Cont.*

Sassi's Principles	Iwamura's Parameters	Description of Relevance
Community	High Contact	Promotes user involvement and cultural responsiveness.
Health and Well-being	Health and Amenity	Supports user well-being and environmental health through building elements.

2.2. Characterizing Traditional Osing Houses

Banyuwangi city is located between 7°43′–8°46′ south latitude and 113°53′–114°38′ east longitude, geographically bordered by Jember and Bondowoso in the west, by Situbondo and Bondowoso in the north, the Bali Strait in the east, and the Indonesian Ocean in the South [20]. The climate conditions in Banyuwangi City include an average temperature of 27.1 °C to 34.0 °C, rainfall of about 2000 mm/year, and a high humidity rate that reaches 95% [21]. Banyuwangi City receives medium rainfall, with a range of 2000–3000 mm/year [7].

Kemiren Village, a village located in Banyuwangi Regency, Indonesia, is different from other villages in Banyuwangi because it has a community whose socio-cultural life is still closely tied to traditional values [22]. The government has designated *Kemiren* Village, Banyuwangi, as a tourist village whose community predominantly comprises members of the *Osing* people, who continue to uphold and practice their ancestral rituals. Most of the traditional houses of the *Osing* tribe are still maintained to this day as tangible evidence of the preservation of local wisdom. The traditional *Osing* house represents the cultural identity of the Banyuwangi region and holds significant social and cultural value, as it has continuously evolved across generations [23]. For the *Osing* people, a house is not an inanimate object but is imbued with life value in every element of its construction. The formation of settlement patterns in *Kemiren* is influenced by several factors including social conditions, culture, land use, land conditions, and relationships between users. Through this process, several parts of the area are formed, namely residential areas, land for farming, courtyards, and areas for tourism. The settlement of the *Osing* tribe is oriented towards the west [24].

The settlement pattern of Kemiren Village tends to extend linearly along the road (Figure 1), and the concept of house orientation is influenced by cosmological orientation [24], which applies throughout the entire village, and has a connection with the surrounding nature. One of the existing regulations is that the orientation of the house should not face the direction of the mountain and the sea. Land use in *Kemiren* Village is highly considered because the *Osing* tribe has a close relationship with its creator, so they protect the land as a form of gratitude. This shows that the culture and traditions performed can support sustainability values.

Figure 1. Settlement pattern of Kemiren Village.

A traditional house is a building with traditional characteristics and one that functions as a residence of a tribe. In addition, traditional houses also represent the culture that exists in a community (Figure 2).

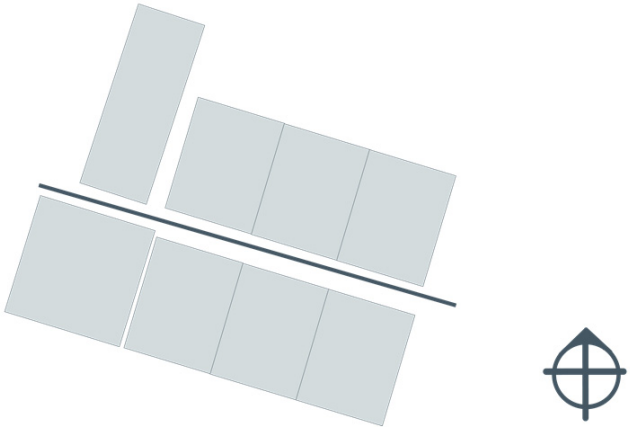


Figure 2. Orientation of *Osing* house.

Traditional houses are formed through the daily activities of their users, culture, beliefs, and the surrounding environmental contexts of indigenous tribes, reflecting their longstanding understanding of social structures and ecological relationships. Traditional houses have several characteristics, and these will be passed down from generation to generation, including structure (Figure 3), form, function, and construction [24]. The structural framework of the *Osing* house comprises several elements:

1. *Soko* is the main structural pillar, consisting of four columns.
2. *Songgo Tepas* is a pillar that supports the roof, also consisting of four columns.
3. *Lambang Pikul* is a tension beam that serves as a support for the *Ander*.
4. *Ander* is a supporting pillar and part of the roof framework.
5. *Penglari* is a wooden element positioned above the *Jait Dhowo* and is the longest structural component.
6. *Jait Dhowo* is a beam that connects the *Soko Tepas* at the front and back, located below the *Penglari*.
7. *Jait Cendhek* is a beam that connects the *Soko Tepas* on the left and right sides, positioned below the *Lambang Pikul*.

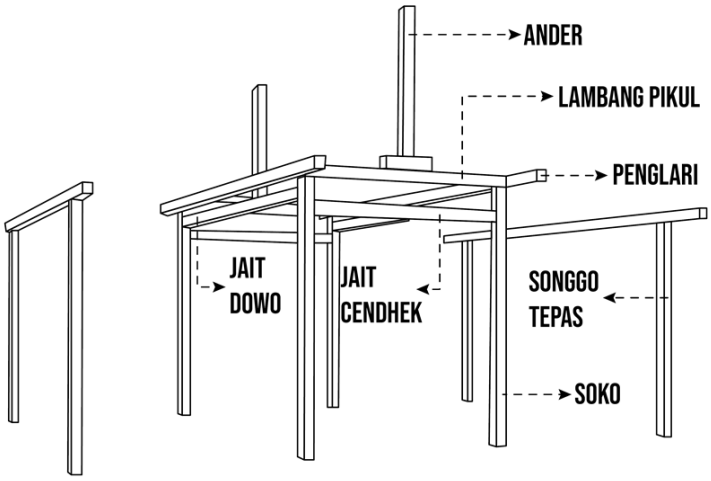


Figure 3. Structure of the *Osing* house.

The shape of the *Tikel Balung* roof is the basic form of the *Osing* house (Figure 4). The roof plane consists of four parts, commonly called *rab*. The *Tikel Balung* type is the main

module and basic form of a typical *Blambangan Osing* house. The existing roof is supported by *Songgo Tepas* and *Soko*. If there are more residents in it, there will be an additional 1 unit of *Tikel Balung* behind it [25]. The typologies of *Osing* houses—Tikel Balung, Baresan, and Crocogan—each have implications for structural performance and sustainability values, while differences in roof span and configuration affect material usage, structural systems, and ventilation.

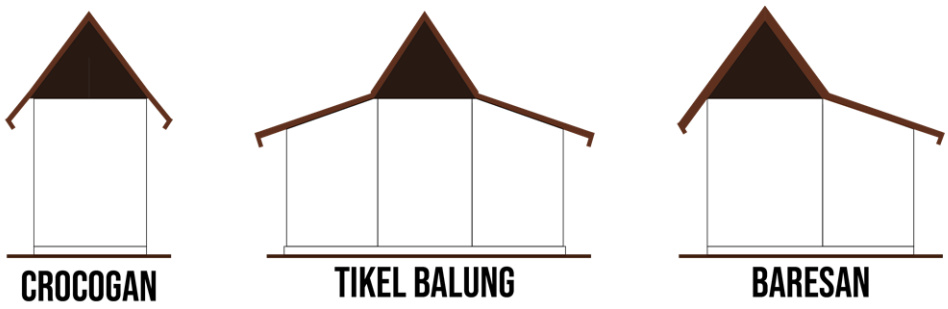


Figure 4. Cerocogan roof shape. Source: [26].

The main materials of traditional *Osing* houses are local, renewable materials that are easy to obtain from the area around the village, making them sustainable [18]. Over time, some renewable materials need to be replaced periodically. The structure of the traditional *Osing* house uses Bendo wood obtained from the Bendo Forest located in Banyuwangi [27]. Some of the characteristics of Bendo wood are that it is light in weight, not too hard, and termite resistant. The parts of the house that use Bendo wood are the *saka tepas* and the wall frame. The wall covering also uses woven bamboo, and the rope binding is made from palm fiber. The roof is covered with clay tiles or *alang-alang*. This material is chosen because Indonesia has a humid tropical climate, so materials with good heat absorption are needed [24].

The structure of the *Osing* house uses double beams to maintain the shape of the house during an earthquake and create rigidity. The use of wooden structures is due to the flexibility and vibration-absorbing properties of wood [28]. The inside of the house does not use ceilings, making the air circulation in the building smoother [21]. The building's response to the environment shows that the *Osing* people have considered the impact of the relationship between their building and the environment. The floor of the house is made higher than the outside area to prevent rainwater from entering the house. The walls of the house are made of woven bamboo to allow natural air to enter the building. The walls and floors of the house are spaced about 10 cm apart to prevent rodents from entering the house and to prolong the life of the walls [24]. The construction of *Osing* houses also considers the sustainability, comfort, and health of the occupants.

The *Osing* house is divided into three necessary parts, namely *bale/nejrumayah/pawon*, while the pavilion is not mandatory (Figure 5). The first part is the *bale*, which is located at the front and functions as a living room and family room including the public zone. The second part, which is the main area of the *Osing* house and the placement of the *songgo tepas* structure, is the *nejrumyah*, which functions as a sleeping room and is separated by a mosquito net, which is a private zone. The rearmost part is the *pawon* and is separate from the house, used as a more private kitchen and family room and also as the service area of the house.

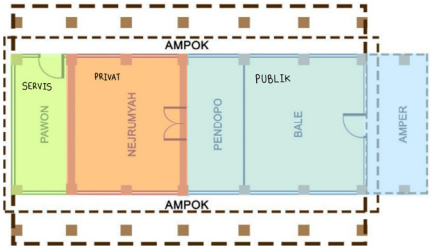


Figure 5. Arrangement of the *Osing* house. Source: [29].

3. Methods

This study adopts a qualitative descriptive method, as described by Groat and Wang (2003) in *Architectural Research Methods* [30]. The research focuses on a single case study as the object of analysis. Through an interpretive analysis process, the study investigates sustainability aspects based on Iwamura's sustainable architecture framework as applied to the traditional *Osing* house.

3.1. Research Strategy

A case study strategy is used, focusing on a traditional *Osing* house located in Kemiren Village, Banyuwangi, Indonesia. This strategy facilitates an in-depth exploration of architectural elements, particularly the structural components of the *Osing* house, with a focus on identifying embedded sustainability values.

3.2. Data Collection Techniques

3.2.1. Literature Review

A literature review was employed to identify theories of sustainability that are relevant to the local context of the *Osing* house. Two theoretical frameworks (Iwamura and Sassi) were identified as having strong alignment with the *Osing* architectural context. However, Iwamura's framework was chosen due to its more integrated and adaptable structure.

3.2.2. Data Collection on *Osing* House Construction Methods

A descriptive study of the structural systems and construction process of the *Osing* house was conducted to support the analysis of sustainability values embedded in each architectural component.

3.3. Data Analysis Techniques

3.3.1. Classification of Structural Elements

Identify and categorize the structural components of the traditional *Osing* house (e.g., foundation, columns, roof framing, walls).

3.3.2. Mapping of Sustainability Values Based on Iwamura's Framework

Low Impact: analysis of material use, construction waste potential, and energy consumption. High Contact: evaluation of environmental harmony, climatic responsiveness, and cultural relevance. Health and Amenity: assessment of user comfort, natural lighting, ventilation, and well-being.

3.3.3. Determining the Sustainability Values

From the mapping above, the sustainability values inherent in the architectural structure of the *Osing* house are synthesized and interpreted, demonstrating how traditional design practices embody modern sustainable principles.

4. Discussion

Traditional *Osing* houses have inherited rules, traditions, and culture which bring values of sustainability in the building process. The construction of *Osing* houses considers the relationship between the building and the environment as its place, humans as users, and economic value as the values of the house elements (Table 3). The sustainability values used by *Osing* houses can be classified into several parameters including energy saving and energy use efficiency, material use efficiency, reducing waste, enjoying the benefits of natural materials, and a safe, healthy, and pleasant environment in the space.

Table 3. Analysis of the *Osing* house structural elements.

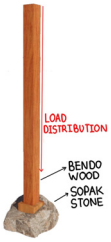
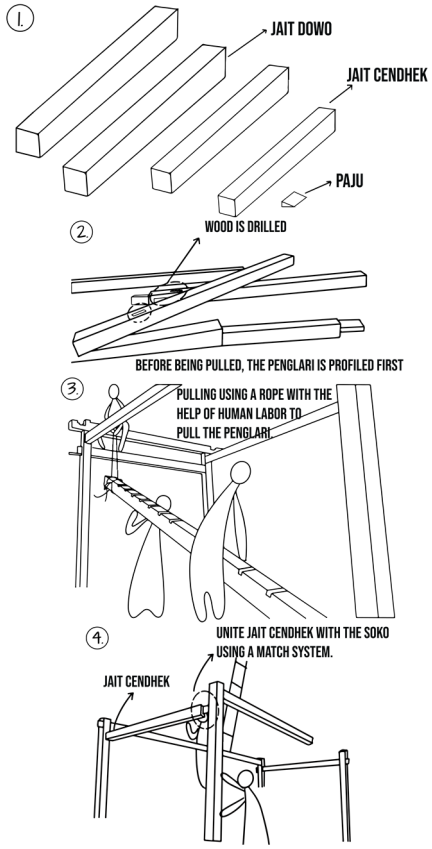
Parameter	Analysis	Interpretation of Sustainable Value
Low Impact Waste Reduction Foundation Construction	 The ubeg foundation rests directly on natural sopak stone without soil excavation, allowing easy dismantling and reuse. This method minimizes construction waste and environmental impact.	Use of materials down to the smallest parts and minimized possibility of construction waste disposal.
Low Impact Energy Saving and Efficient Energy Use Beam Installation Process	 Energy efficiency by reducing the use of heavy equipment that requires fuel to operate.	Use of human power for efficiency and energy saving due to knock-down structure and light weight.

Table 3. *Cont.*

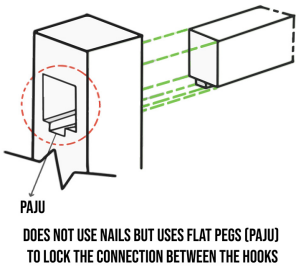
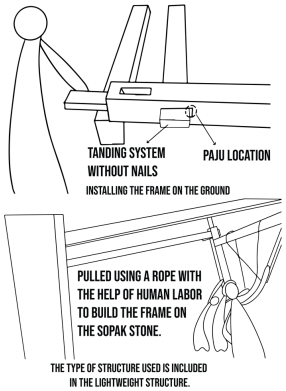
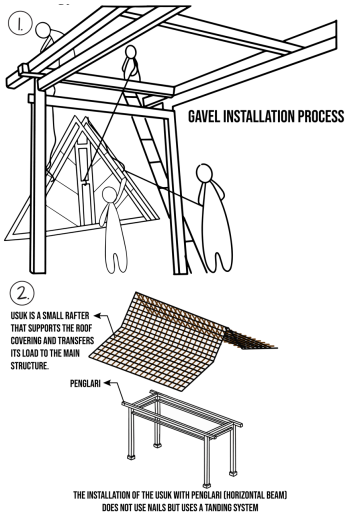
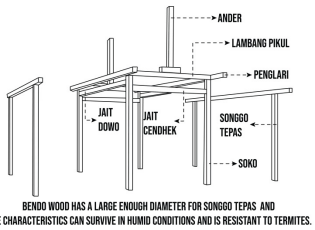
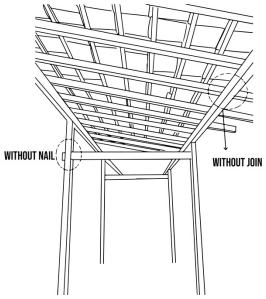
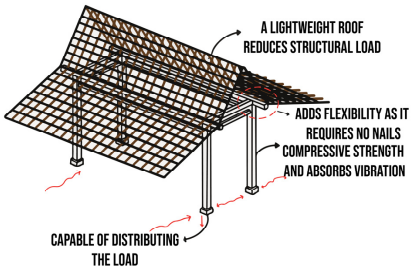
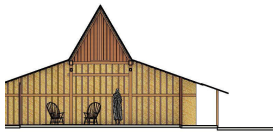
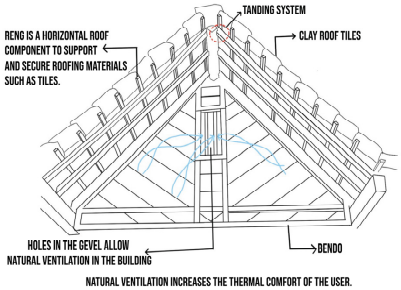
Parameter	Analysis	Interpretation of Sustainable Value
Low Impact Energy Saving and Efficient Energy Use *Tanding* System		Energy efficiency occurs because the building can be dismantled without the need for special tools and does not require a long time.
Low Impact Energy Saving and Efficient Energy Use Construction Process		The *ubeg* foundation is above the ground, so it does not require the process of dredging the soil using heavy equipment whose energy sources come from non-renewable energy.
Low Impact Energy Saving and Efficient Energy Use Roof Construction Process		The knock-down system allows the material to be reused in other projects and makes packaging easier as it is already profiled.

Table 3. *Cont.*

Parameter	Analysis	Interpretation of Sustainable Value
Low Impact Efficient Use of Resources Use of Local Material		Use of local materials around the village to reduce carbon footprint and streamline resource use.
Health and Amenity Enjoying the Benefits of the Natural Environment *Osing* House Structure	 	The structure of an *Osing* house uses materials whose characteristics match the environmental conditions.
Health and Amenity Safe, Healthy, and Pleasant Indoor Environment Wooden Frame Structure	 The use of wooden frames for the main structure is able to absorb vibrations and has resistance to compression [28].	The wooden structure can absorb vibrations and is lightweight and has the flexibility to support building safety.
Health and Amenity Safe, Healthy, and Pleasant Indoor Environment *Osing* House *Gevel*	 	

The parameters of energy saving and energy use efficiency are evident in the use of lightweight structures for all parts of the house, including the roof, and by minimizing excavation so that no heavy equipment is required for construction or material handling; additionally, the knock-down structural system, which uses traditional joinery techniques without the use of nails, allows the entire house to be disassembled from the foundation to the roof, thus further reducing energy consumption and resource use. These joinery methods include mortise-and-tenon joints—a traditional timber connection technique that employs wooden pegs instead of nails or screws, enabling components to be reused. Documenting these techniques in detail would enhance the understanding of how traditional construction methods support circularity and resource efficiency. The efficient use of resources and waste reduction are achieved by maximizing the use of *Bendo* wood as the primary structural material down to its smallest components and using the ubeg foundation technique. The benefits of natural resources can be enjoyed by using local and natural materials located around *Kemiren* Village, whose characteristics are in accordance with climatic conditions. A safe, healthy, and pleasant indoor environment is ensured by selecting vibration-absorbing wood that enhances seismic resilience and incorporating climate-responsive features such as certain roof shapes, height, and facade gaps to optimize thermal comfort. Notably, not all of Iwamura's sustainability parameters can be applied in this study. Based on the analysis of the traditional *Osing* house, only the parameters of *low impact* and *health and amenity* are considered relevant. These align with the use of local materials, knock-down construction techniques, environmental responsiveness, and the application of health and amenity principles, particularly in achieving thermal comfort.

5. Conclusions

The analysis of structural elements in traditional *Osing* houses is in line with Iwamura's sustainability parameters:

a. Low Impact: The application of energy saving and energy efficiency by maximizing human power for building construction. Optimizing the use of renewable materials is achieved by selecting local materials located around *Kemiren* Village.
b. Health and Amenity: This involves two parameters, namely enjoying the benefits of natural resources, and ensuring a safe, healthy, and pleasant indoor environment. This is realized by using local materials suitable for the climatic conditions in Banyuwangi, and by using safe structures.

The context of ancient social problems is different to that of today's society. Humans have progressed in the field of technology so that they are able to develop inherited, traditional values to meet their present-day needs. Based on the results of this analysis, *Osing* houses tend toward low impact and health and amenity parameters. This study highlights how traditional *Osing* houses embody sustainable values through their use of local materials, responsiveness to the environment, and cultural continuity. These values, which have been practiced since long before the concept of sustainability became a global concern, offer relevant lessons for addressing today's environmental challenges through architecture.

The finding of this study is that the knock-down structure of *Osing* houses, which allows the building to be dismantled from foundation to roof, can be adapted for use in modern vertical architecture. This system not only provides flexibility in construction but also supports material reuse, reduces construction waste, and aligns with sustainable principles. Adapting traditional construction strategies in high-rise buildings can contribute to the development of an architectural environment that responds to both cultural values and urban needs.

6. Patents

Sustainable architecture is a process that considers socio-economic/environmental aspects in its implementation. The parameters used by Iwamura and Lányi were adopted as rules in the process of researching the relationship between structural elements and sustainability values. Traditional houses pass down rules, traditions, and culture from generation to generation. Existing traditional values are the result of the lives of previous communities who continued to learn to survive and incorporate sustainability values. The *Osing* people consider how to ensure that the buildings they construct do not damage the environment, because protecting the environment is one of their forms of gratitude to the creator. The *Osing* house building construction uses a lightweight and demountable structure that allows the building to be moved.

An *Osing* house is a growing house that uses a knock-down system that allows it to be disassembled according to the needs of its users. The *Osing* house grows horizontally, so it consists of several modules (Figure 6), and the knock-down system thus falls under the low-impact parameter. In terms of structure and safety, the *Osing* house uses double beams to maintain its shape when in an earthquake. The design proposal is based on the principles of Iwamura, namely low impact, which affects the knock-down system and the use of manual tools to install and dismantle the mezzanine floor, and health and amenity, which affect the use of double beams to maintain its shape during an earthquake.

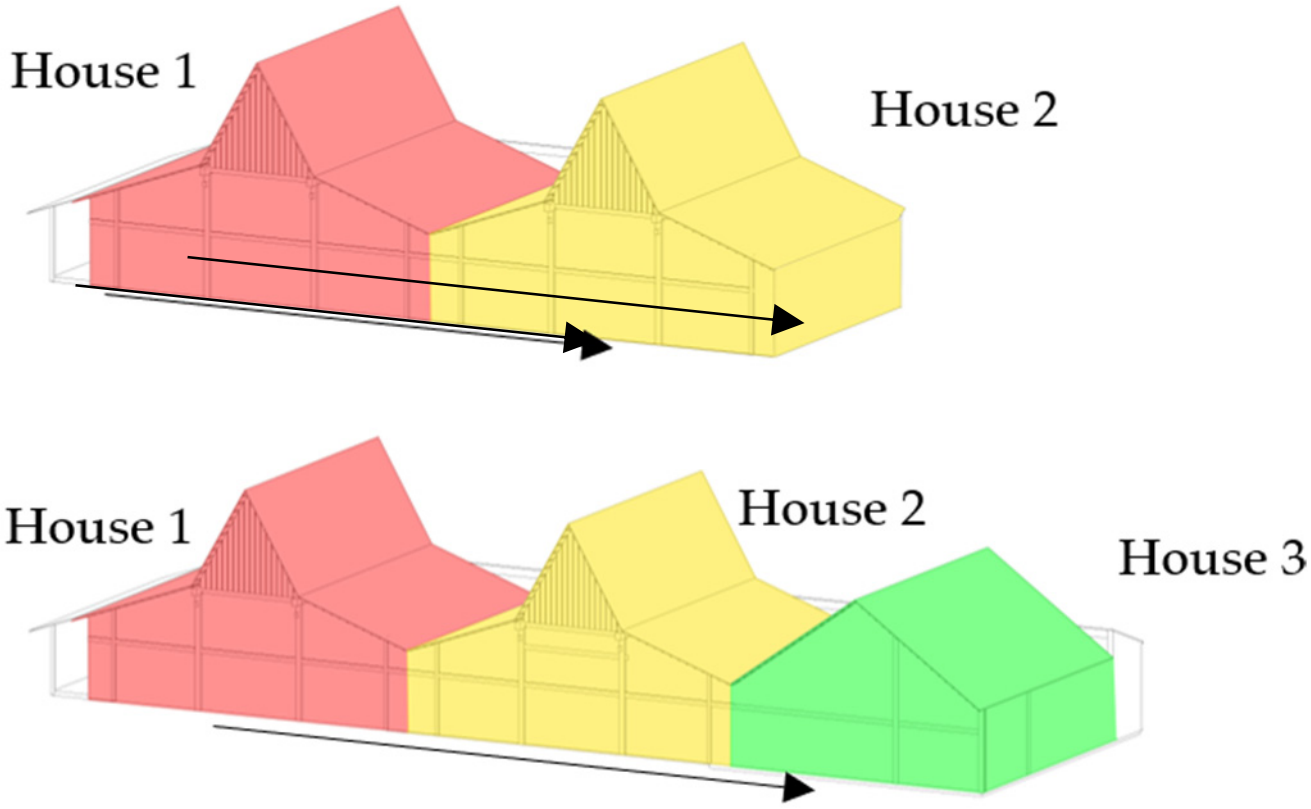


Figure 6. *Osing* house growth.

The application of structural system elements from *Osing* houses in today's buildings is based on a knock-down system. The *Osing* house traditionally expands horizontally in response to user needs, and this concept can be adapted into a vertical structural system incorporating mezzanine floors, enabling flexible modifications to accommodate evolving spatial requirements (Figure 7). The structural system uses a matching system that does not use nails as a link between elements so that it can be disassembled when not in use. It

also features mezzanine floors so that the vertical module per unit is not too high because a wooden structure is included in the lightweight structure.

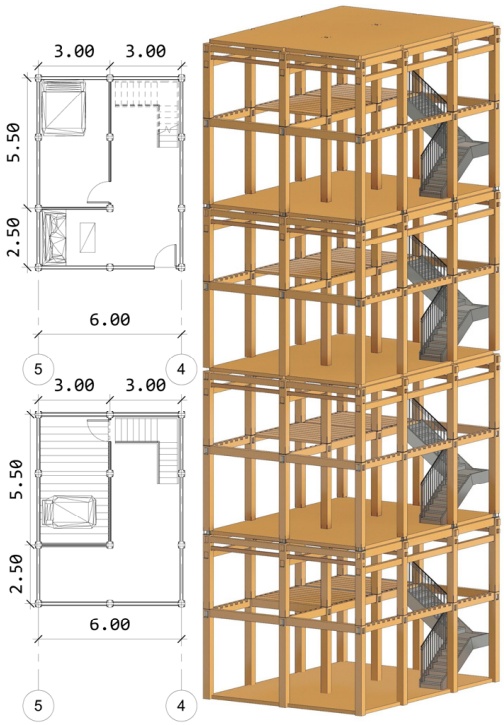


Figure 7. Application of structural elements of the *Osing* house in a vertical design.

Author Contributions: Conceptualization, C.P.; methodology, C.P.; writing—original draft preparation, C.P.; writing—review and editing, A.D.H. and L.S.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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