

## Article

# An Integrated Framework for Preservation of Hawaii Indigenous Culture: Learning from Vernacular Knowledge

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**Abstract:** Vernacular architecture represents the traditional architecture that developed over time within a particular culture or region that embodied indigenous knowledge. These buildings provide an invaluable cultural heritage, and learning from them is an important way to preserve indigenous culture. However, the negative view commonly held about indigenous knowledge in architectural theory and historical research that developed during the colonial era has not begun to change; the indigenous knowledge embedded in vernacular architecture has been ignored. This article discusses a proposed framework in which we can learn from vernacular architecture to preserve indigenous culture, including studying traditional building techniques, incorporating traditional materials and designs, adapting traditional designs to contemporary needs, involving local communities, and encouraging sustainable building practices. This proposed framework is applied to learning from Native Hawaiian architecture as a way to demonstrate its practicality and necessity. By studying the designs, materials, and techniques used in vernacular buildings, we can gain a deeper understanding of the cultural, environmental, and social contexts in which they were created.

**Keywords:** vernacular architecture; indigenous knowledge; native Hawaii



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## 1. Introduction

Hawaii is an archipelago located in the Pacific Ocean and is the only U.S. state that is not located in North America. It is a territory composed of eight major islands and numerous smaller islands and atolls. The state has a diverse population, with Native Hawaiians, Asian Americans, and Pacific Islanders being the largest ethnic groups. Hawaii's culture is a unique blend of Native Hawaiian, Asian, and Western influences, which is reflected in its art, music, food, and traditions. However, despite the state's rich cultural heritage, Hawaii faces significant challenges in preserving its historic sites and cultural resources [1]. The state is home to many historic buildings, landmarks, and archaeological sites that provide a window into Hawaii's past. Unfortunately, many of these sites are under threat from natural disasters, urban development, and human activities such as vandalism and looting. As a result, efforts are being made to protect and preserve Hawaii's cultural heritage by documenting and conserving historic sites and educating the public about the importance of preserving the state's cultural resources [2]. We first outline the rationale for why a new framework integrating indigenous knowledge by learning from vernacular architecture is needed in the case of the Native Hawaiian community. Three prominent factors threatening the existence of the Native Hawaiian community are cultural degradation, economic hardship, and climate change impact.

### 1.1. Cultural Identity Degradation

Hawaii was first settled by Polynesian voyagers from the Marquesas Islands approximately 1600 years ago [3]. The Hawaiian people had a deep reverence for the land and

the ocean and recognized the importance of sustainable living practices. The concept of “kuleana” (right and responsibility) reflected their belief in the interconnectedness of all living things and the need to care for the land and environment. Native Hawaiians, especially those who practice traditional Hawaiian culture, believe it is their kuleana to care for the aina (land) as it does for them. What can be seen in traditional Hawaiian architecture encapsulates that very idea, utilizing every natural material that has been cultivated within soil and being sure to replenish it. In the Hawaiian worldview, humans are not the owners of this land; rather, humans are temporary beings placed upon this soil as a means to live in harmony with nature. Overall, the history and culture of Hawaii provide an example of a sustainable and harmonious relationship between people and their natural environment.

However, the cultural identity erosion of Native Hawaii is a real and complex issue that stems from a long history of colonization and cultural suppression [4]. One of the most significant factors contributing to cultural identity degradation in Hawaii was the suppression of the Hawaiian language and cultural practices in schools and other public institutions. For many years, the use of the Hawaiian language was banned in schools, and traditional cultural practices such as hula were discouraged or even criminalized [5,6].

In addition to these formal measures, the Hawaiian population was subject to economic and social pressures that undermined traditional cultural practices. The introduction of Western-style clothing, food, and housing, for example, led to changes in traditional subsistence practices and contributed to the erosion of traditional cultural practices. Meanwhile native Hawaiian culture has been wrongfully portrayed as an idyllic paradise to visitors with the tourist industry generating over USD 17 billion each year [7]. The promotion of cultural tourism in Hawaii has long been criticized as contributing to the degradation of native culture and indigenous knowledge as well as the environmental quality in the form of continuous colonization [8,9].

### 1.2. Economic Hardship

The State of Hawaii has the highest rate per capita of homelessness due to the combination of high-cost living and a shortage of affordable housing. Compared to the State as a whole, Native Hawaiians face worse economic challenges: 50% of homeless individuals identify as Native Hawaiian or Pacific Islanders [9]. The housing shortage and inequality faced by Native Hawaiians was exacerbated by U.S. military occupation on the island, which accounted for approximately 150,000 acres of the Hawaiian Islands all together. This is particularly the case on the most populated island O’ahu, where 22% of the island is used by the U.S. military and this is expanding [10]. Therefore, Native Hawaiians have to compete for home ownership with non-Native military members who have increased access to affordable market housing through VA loans and housing allowances [11]. In addition to housing, Native Hawaiians have a harder time paying for essentials goods, such as food, child care, and medicine [12]. Due to the lack of economic means and access to resources (e.g., food), Native Hawaiians also have to deal with a range of both physical and mental health issues. Native Hawaiians have higher rates of coronary heart disease, strokes, cancer, and diabetes [13].

### 1.3. Climate Change Impact on the Indigenous Communities

Hawaii is facing a number of environmental challenges related to climate change, including rising sea levels, more frequent and intense hurricanes, and water contamination. Sea level rise is a particularly pressing issue in Hawaii as it can lead to coastal erosion, damage to infrastructure and housing, and increased salinization of fresh water resources [14]. Native Hawaiians are among the populations most vulnerable to the impacts of climate change. As an island community with a rich cultural heritage, they are deeply connected to the natural resources and ecosystems that are being threatened by the changing climate. One of the most significant ways that Native Hawaiians are being impacted by climate change is through the loss of important cultural and natural resources [15]. For example,

rising sea levels are causing damage to traditional fishing and agriculture sites, which are critical to the survival and well-being of many Native Hawaiian communities.

In addition to direct impact through resource constraints, climate change is affecting the affordability and availability of housing in Hawaii. As insurance premiums rise in response to the increased risk of natural disasters, many building owners showed difficulties in securing affordable coverage as the building materials' cost is on the rise. Another way that Native Hawaiians are affected by climate change is through displacement and relocation. As sea levels rise and the risk of flooding and coastal erosion increases, many Native Hawaiian communities are being forced to abandon their homes and move to higher ground [16]. This can lead to the loss of community and cultural ties, as well as to economic hardship and health problems.

Taken together, the challenges of cultural identity erosion, economic hardship, climate change effects, and ecosystem degradation are making it harder for the indigenous communities that have already faced hardship to maintain, repair, and rebuild their properties while maintaining cultural relevance. Overall, the impacts of climate change on Native Hawaiian communities highlight the importance of taking action to create climate-resilient built environments and to support communities that are at the forefront of its impacts. To this extent, an integrated framework is proposed to tackle the problems; such a framework is anchored on learning about vernacular architecture, with the aim to build up climate resilience and preserve indigenous culture.

## 2. Theoretic Background

### 2.1. Global Cultural Diversity and Vernacular Architecture

UNESCO (United Nations Educational, Scientific and Cultural Organization) defines cultural biodiversity as "the wide range of knowledge, beliefs, arts, morals, customs, laws, and other capabilities and habits acquired by humans as members of society" (UNESCO, 2002). UNESCO emphasizes the importance of preserving and promoting cultural diversity as it plays a significant role in promoting social cohesion, sustainable development, and peaceful coexistence among different cultures and communities.

The term "cultural biodiversity" is often used when it comes to indigenous or traditional knowledge; that is, the knowledge, practice, and belief of indigenous communities that have passed down through generations [17]. In recent decades, there has been a growing awareness of the negative impact of cultural homogenization resulting from globalization [18]. This awareness has sparked increased interest in promoting and preserving local cultures, leading to the emergence of studies and research on architecture that is recognized internationally as "vernacular" or traditional. The rapid pace of industrialization has resulted in the introduction of standardized urban, architectural, and technological solutions, which have replaced traditional models and eroded the link between the environment, socio-cultural context, and territory. This loss of the link between territory, the environment, and socio-cultural context has been attributed to the progressive introduction of standardized solutions resulting from industrialization phenomena.

The preservation and recovery of cultural diversity has the potential to foster cultural identity within societies, thereby providing a sense of belonging and pride for individuals and promoting cultural continuity across generations. Moreover, it may lead to social cohesion by engendering mutual understanding and respect among different groups, preventing social exclusion, and encouraging cooperation and dialogue among diverse communities. Furthermore, the environmental benefit of preserving cultural diversity is a critical yet often overlooked aspect. Cultural diversity is closely linked to environmental sustainability as it often involves traditional knowledge and practices that promote sustainable resource use and conservation. Thus, preserving cultural diversity may also serve to protect the natural environment.

The role of vernacular architecture in perceiving cultural diversity is significant. Vernacular architecture can be seen as a form of tangible cultural heritage that represents the knowledge, skills, and beliefs of a particular community. The author of [19] pointed

out that vernacular architecture shows us the various, distinctive, and often beautiful and ingenious ways in which people, throughout the world and over time, have imagined, designed, used, and maintained their built environments. In the following section, the proposed framework for learning about vernacular architecture is outlined.

## 2.2. Indigenous Knowledge, Biodiversity, and Sustainable Development

The theoretic foundation of this integrated framework is based on the notion “Conservation of indigenous knowledge serves conservation of biodiversity” proposed by Dr. Dennis Michael Warren in a keynote address at the International Conference on Conservation of Biodiversity in Africa in 1992 [20]. Indigenous knowledge encompass a wide range of fields such as agriculture, medicine, and construction. Studies that depicted indigenous communities and their knowledge as primitive, simple, and static are countered by rapidly expanding empirical evidence and datasets generated in a wide array of disciplines, such as agriculture [21], biology [22], medicine [23], and social science. Those emerging research studies describe the complexity and sophistication of many indigenous natural resource management systems.

International and national development agencies have recognized the value of integrating indigenous knowledge in decision making with regard to sustainable development. Posey (1985) [24] pointed out that despite the rareness of a serious investigation of indigenous ethnobiological and ethnoecological knowledge, a few studies have shown the indigenous knowledge of ecological zones, natural resources, agriculture, aquaculture, and forest management to be far more sophisticated than previously assumed. Especially in the field of agriculture, as early as 1992, the U.S. National Research Council stated “If indigenous knowledge has not been documented and compiled, doing so should be a research priority of the highest order. Indigenous knowledge is being lost at an unprecedented rate, and its preservation, preferably in data base form, must take place as quickly as possible”.

Despite the value of studying indigenous knowledge being acknowledged in other fields, the negative view commonly held about indigenous knowledge in architectural theory and history research during the colonial era has, however, not begun to change; the indigenous knowledge embedded in vernacular architecture has been ignored and downgraded as primitive.

## 2.3. The Loss of Indigenous Culture and Vernacular Knowledge in Hawaii

As explained in the previous sections, there is a common consensus that the role of vernacular architecture in preserving cultural diversity is significant. Vernacular architecture can be seen as a form of tangible cultural heritage that represents the knowledge, skills, and beliefs of a particular community. However, vernacular knowledge and indigenous culture is disappearing at a fast speed. Benham and Heck pointed out that since the early 1800s, “educational policy in Hawai’i emphasizing efficiency has resulted in institutional structures that have degenerated Hawaiian culture, self-image, and sovereignty.” [25]. The equitable dissemination of educational opportunities and its consequent enhancement of economic and social status has been impeded for indigenous Hawaiians. Moreover, the educational curriculum has historically disregarded the cultural practices and vernacular knowledge of the native community [4,26]. These education policies were often overtly, or covertly, racist and reflected wider cultural views prevalent across the United States regarding the assimilation of groups into the American mainstream culture [25].

Under the context described above, as a platform that embodied indigenous culture and vernacular knowledge, vernacular Hawaiian architecture was described by a non-native scholar as vulnerable to the local environment; hence contributing to its quick disappearance. In the report published in 1979 and commissioned by the U.S. National Park Service western regions, an architectural historian and an architect (both non-native) stated “Buildings of this type of indigenous architecture, found in plantation camps and in residential areas in Honolulu, Kalaupapa, and many other places throughout the islands, are rapidly disappearing. This type of architecture is declining, in part due to the main

material used in construction—wood. The wood gets ravaged quickly by the climate and by termites. In other areas of the islands the structures are falling prey to the pressures of development.” [27]. In addition, in the current context of the globalization of construction techniques and the high requirements for comfortable dwellings, the vernacular Hawaiian architecture is almost non-existent in the current modernized community. These buildings can only be found in cultural heritage centers.

### 3. Proposed Framework: Learning from Vernacular Architecture

#### 3.1. Overall Approach

The main difference between indigenous knowledge and modern knowledge based on scientific findings can be understood using the Nonaka knowledge spiral, a model that describes how knowledge is created and shared within organization and society [28]. The Nonaka knowledge spiral distinguishes tacit knowledge from explicit knowledge. Explicit knowledge is knowledge that has been articulated and codified in a manner that facilitates its easy expression, capture, storage, and reuse. This type of knowledge can be transmitted via databases, books, manuals, and messages, and it represents a significant proportion of modern knowledge. On the other hand, tacit knowledge is difficult to formalize and communicate. It comprises a set of skills, mental models, beliefs, and perspectives that are firmly entrenched in an individual’s actions and thoughts in a particular context. It is often partly made up of technical skills and partly of mental models, beliefs, and perspectives. Through generational accumulation, tacit knowledge has become so settled that it is taken for granted and cannot be easily expressed [17].

The effective way to extract and learn the tacit indigenous knowledge embedded in vernacular architecture is to decompose this knowledge into digestible components. Vernacular architecture has been widely understood as “the architectural language of the people with its ethnic, regional, and local dialects: the product of ‘non-experts’” [29]. Vernacular architecture refers to the traditional buildings and structures that have developed over time within a particular culture or region, often constructed using locally available materials and techniques. These buildings represent the cultural and historical identity of a region or community and are often considered to be invaluable cultural heritage.

#### 3.2. Method

Abductive reasoning, a qualitative reasoning technique that derives the simplest and most probable conclusion from a set of observations, is utilized in this project. It was originally proposed and advanced by Charles Sanders Peirce, an American philosopher, in the latter part of the 19th century [30]. It is a useful tool to generate hypotheses and explanations in a wide range of research fields, such as archaeology [31], medicine [32], and marketing research [33]. It is also frequently used in built environment research [34–36]. Six steps were used to derive the five components of the proposed framework: (1) identify framework objective, (2) review literature related to Hawaii vernacular architecture and knowledge, (3) generate hypotheses, (4) evaluate hypotheses, (5) test hypotheses with case study (refer to Section 4), (6) draw conclusion. The proposed framework is composed of five components in order to create, deliver and share the tacit knowledge embedded in vernacular architecture: (a) study tradition building techniques, (b) incorporate traditional materials and designs, (c) adapt traditional designs to contemporary needs, (d) involve local communities, (e) encourage sustainable building practices.

#### 3.3. Study Traditional Building Techniques

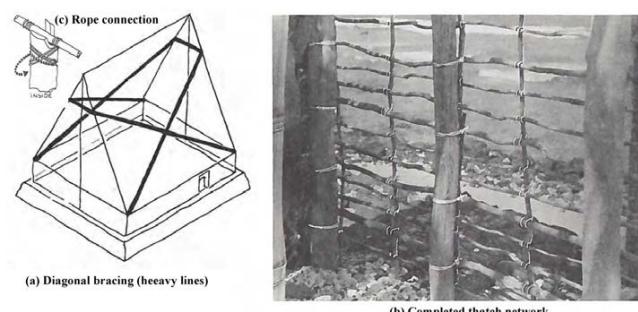
Vernacular architecture is often constructed using locally available materials and techniques. Through the examination of these building construction techniques, a deeper understanding of the regional resources and environmental conditions can be gained. Furthermore, studying vernacular architecture can offer insights into the social and cultural contexts in which these techniques were developed and employed. For instance, the use of mud bricks in the construction of traditional buildings in specific areas may

provide valuable insights into the environmental and cultural factors that have shaped this construction method.

The roots of Hawaiian vernacular architecture were truly birthed by a combination of the Hawaiian Islands' natural resources and traditional construction techniques brought from Marquesas Island. The people of Marquesas Island were the very first known settlers to arrive in Hawaii. They gathered what their Polynesian brothers and sisters used to design and implemented this knowledge into their structures. In most Polynesian architecture (Hawaii, Fiji, Tahiti, New Zealand, and New Guinea), rectangular floor plans always prevailed.

Each hale was built according to a person's rank. Small hale were approximately three to four feet high and were dwelling grounds for individuals of lower social status. Larger hale were approximately 12 to 14 feet high and were for their ali'i and others alike. In this particular home, there was a basement room where most Hawaiians preferred to dwell. Despite the lavishness and abundance of rooms within the palace of Princess Ke'elikolani, she inevitably lived in the basement because of its cooling properties. Although each hale served its different purposes, they all had one thing in common: they all boasted the same foundation, structure, tools, and materials. The construction of a Hale was a team effort and all members of the community participated; that is also how the indigenous construction knowledge was passed down from one generation to the other. Without a system of measurement against a standard (e.g., meter), Hawaiian people used parts of the human anatomy, string, or sticks to determine measurement. The upper size limit of houses was set by the usable lengths of timber that formed the component frame members. Practical length limits were set by the available timbers for wall plates and ridges. The technique of splicing or joining timbers through overlapping and binding was practiced in the application of thatch purlins, and doweling was practiced in canoe assembly, but neither technique was apparently used to lengthen timbers to be used to frame a house [37].

The sophistication of the building techniques of vernacular Hawaiian architecture is particularly reflected in large structures, such as a chief house or temple. As illustrated in Figure 1, a mature solution is offered to resist a high lateral load caused by high wind speeds and hurricanes. First, a diagonal bracing system was created to stiffen the entire house and eliminate sway from end to end. No joints were needed, and component parts were lashed together at meeting points with rope made from leaf fibers. The lashing included crossing the two long timbers on the front side and those on the back side. Elimination or minimization of the side sway caused by the lateral load was achieved by the thatch network in a manner similar to a modern lateral wall or frame. Before the thatch network or diagonal braces were installed, one person swayed the ridge pole back and forth in a total movement of about five inches. With the thatch network added, the movement was reduced to less than two inches, and after the diagonal bracing was installed, no sway could be detected even if several men tried to induce it. Such structurally sound houses can withstand high winds and other natural disasters, and these design principles and techniques can be applied to modern constructions located at wind-prone sites.



**Figure 1.** Structure and construction. (a) Diagonal bracing. (b) Completed thatch network (inside view). (c) Rope connection.

### 3.4. Incorporate Traditional Materials and Designs

The use of locally available materials and construction techniques familiar to local builders is one of the most relevant features of vernacular architecture, and can be used to identify regional differentiation [38]. By incorporating traditional materials and designs into contemporary architecture, we can preserve the cultural identity of a region or community. This can also help to create a sense of continuity between the past and present. For example, the use of traditional motifs and patterns in the design of modern buildings can help to maintain the cultural heritage of a region while also creating a visually striking and unique building. Furthermore, the use of traditional materials and designs can generate economic benefits, as it can attract cultural tourism and promote regional crafts and skills.

Every hale was constructed using locally sourced and harvested materials. The three most commonly used materials were: timber, rope, and leaves. Wood framing (posts and rafters) was created using the straight portions of trunks and branches of unmilled hardwood. The best hale were usually constructed using: naio, uhiuhi, kauila, mamane, and koa (although koa was used more for canoes). Inferior hale oftentimes used ohia lehua wood, and hale for the gods used lama. However, if a hale was to be designed today, unmilled hardwood such as: ironwood, kiawe, eucalyptus, strawberry guava, ohia, and mangrove are all acceptable wood materials because they can still be found on the Hawaiian Islands (Honolulu). As illustrated in Figure 2, the roof and siding were composed of either grass or leaves found on the islands, usually pili or coconut leaves. If a hale was to be designed today, pili, kualohia, pueo, kawelu, sugarcane leaves, and ti leaves are all acceptable materials (Honolulu). To lash structural members together, Native Hawaiians would use a natural cord from coconut fibre. If created today, it would need to have the capability to carry a weight of at least 400 pounds. Cords that were used for floating purlins and thatched materials withstood weights of approximately 100 pounds (Building code chapter 16). No metal was used throughout any of these structures and should not be used in the modern building of a traditional hale.



**Figure 2.** Traditional hale and building materials.

### 3.5. Adapt Traditional Designs to Contemporary Needs

While traditional designs may not always be suitable for modern living, they can still provide inspiration for contemporary architecture. By adapting traditional designs to contemporary needs, we can create buildings that are both functional and culturally sensitive. For example, traditional courtyard houses in certain regions can be adapted to include modern amenities and technologies while still maintaining the traditional design elements and cultural identity of the building.

The hale or house was the basic spatial DNA of Hawaii architecture, it served different functions: sleeping quarters and a space for eating, cooking, working, and worship. The types of Hawaiian hale included Hale Heiau, which was a place many Hawaiians utilized to worship the Hawaiian gods such as Lono, Ku, and Madame Pele. Hale Mua was the

sleeping ground for men, where women were forbidden to enter (anyone who broke kapu faced death), and Hale Noa was the sleeping ground for the ohana (family). Hale Aina was where women ate and men were forbidden, and Hale Kahumu was where all food was prepared. Hale Kua was where women went to work weaving mats and others alike, and Hale Wa'a was the place Hawaiians stored their canoes. In Hawaiian indigenous architecture, groups of hale were located together so that a common space was created between the buildings, which was used by all the community members and numerous visitors.

In modern society, there is no need to separate men and women when eating; hence, Hale Mua could be used for other activities reserved for women. Other functions of the different hale are still relevant; for example, separate bedrooms for men and women who do not belong to the same family or for a designated cooking space.

### 3.6. Involve Local Communities

In order to preserve indigenous culture, it is important to involve local communities in the design and construction of buildings. This can help to ensure that the buildings reflect the cultural values and needs of the community. By involving local communities, the new development can also help to promote a sense of ownership and pride in the cultural heritage of the region.

In Hawaiian tradition, construction was a collaborative activity, and all Native Hawaiians followed a similar system to build their hale, regardless of whether it was for personal or the chief's use. While the men were in the mountains cutting down trees, others, typically kupuna (elders), were down by the shore braiding cords for the structure and wrapping them into 12 to 18 inch balls. These cords were used in place of nails and screws and were made of aha (coconut fibre) cable [39]. Women and children went out in search of pili grass used for the roof of their hale. Once all materials were gathered on the land, they began cutting away all of the sapwood from their wood selection to ensure the durability of each post. They then planted these posts, which were typically six to eight inches in diameter, three to four feet apart. They then created grooves at the top of each post and placed small wooden poles in the grooves that served as rafters. These rafters were secured to each post with the fibrous roots of an 'ie'ie, a dense wooden vine that is a part of the pandanus family. Joints of the Hawaiian house were mechanically sound, and no nails or dowels were needed [37]. For added stability, a stick proportional to the rafters was set below it, which soon became known as the lohelau or wall plates. These plates were eventually set on top of posts to protect the interior from flood waters. This became known as the sill. Once the framework was complete, the roof and siding took form. The grass and leaves that the keiki (children) and wahine (women) had gathered were laid atop the rafters and sometimes the posts. The interior of each hale was fitted with a well paved floor and covered with grass. Once complete, mats that were woven together by the wahine were set on top to provide a cleaner, more comfortable look. The best hale, however, were equipped with a paved foundation and smooth pebbles often created from lava.

Table 1 lists the various components that can be learned from vernacular architecture in three categories: materials, techniques, and design. These components have been applied in the case study (refer to Section 4).

### 3.7. Encourage Sustainable Practice Derived from Native Science

Many of the design and construction practices in vernacular architecture are at the core of sustainable design principles that are environmental friendly and less energy-intensive than is found in many modern buildings [40]. Vernacular architecture in Hawaii has historically been viewed as a sustainable practice. This is due to its reliance on locally available materials and construction techniques that are adapted to the natural environment. For example, the use of banana leaves and pili grass for roofing is a sustainable choice because of its abundance and ease of replacement. Furthermore, the use of cords made of

coconut fiber, as opposed to nails or screws, can significantly reduce the need for imported metal hardware.

**Table 1.** Essential components learned from vernacular architecture.

	Conventional Architecture	Vernacular Architecture
Materials	Concrete, imported timber Screw, nail, fastener	Local unmilled hardwood (e.g., ironwood, kiawe, eucalyptus, strawberry guava, ohia, mangrove) Natural cord
Techniques	Post and beam system Rigid connection	Diagonal bracing system Thatch network (functions as lateral system)
Design	One large space Solid exterior enclosure Mechanical ventilated space	Small-scale separate room (mimicking hale) Semi-closed spaces Natural ventilation

In terms of design, Hawaii's mild temperature throughout the year, along with moderate humidity and the persistence of trade winds, provides favorable natural conditions for the building's occupants. As a result, natural ventilation and appropriate building orientation can often obviate the need for heating and cooling systems. This reliance on passive cooling systems helps reduce energy consumption and the environmental impacts associated with active climate control systems. Recently, a meta-analysis showed that the use of passive cooling techniques in traditional buildings in certain regions can provide inspiration for modern buildings that are more energy-efficient and sustainable [41].

However, contemporary construction practices in Hawaii have increasingly employed conventional building materials and techniques that may not be congruent with sustainable practices. For instance, the construction of tightly enclosed structures without adequate openings may not be optimal in a climate that has natural ventilation available throughout the year. Consequently, such practices necessitate the dependence on air conditioning systems to cool buildings, leading to increased energy demands and various associated environmental impacts.

In recent years, sustainable design in a built environment has become mainstream practice, and sustainability science in the building industry has increasingly been coupled with a technocentric approach to environmentalism that aims to sustain the ecosystem [42]. For example, a wide range of smart sensors and computer-aided design tools help designers, builders, and owners to monitor building performance. However, these technocentric and development-based approaches presuppose that the planet and human societies require improvement and depend upon Western science [42]. While the Western scientific method has strength in providing methodologies and the associated metrics necessary for the quantification and monitoring of sustainable development and practice over time, its general approach, however, is to seek to dominate and question the natural approach [42]. Contrary to Western scientific knowledge, indigenous knowledge has developed a system that aims to sustain reciprocal relationships between nature, culture, and humans. Many scholars have pointed out that indigenous communities utilize scientific approaches that are rigorous in their own methods and rely on long-term observations to create indigenous knowledge; therefore, scholars defined the indigenous knowledge system as Native science [42–45].

#### 4. Case Study

##### 4.1. Background

This case project focuses on the redesign of the Maunalua Fishpond Heritage Center (MFHC) building. MFHC is a non-profit organization established in 2007 to protect freshwater springs and cultural sites surrounding the freshwater fishpond. The current restoration projects include Kanewai Springs and Kalauha'iha'i, two freshwater ponds adjacent to Kuli'ou'ou Ridge. Kanewai Springs is a vital natural spring that supplies the

ocean with clean water, and is referred to as “where the mountain gives birth to the ocean” by the MFHC website.

The project site holds archaeological and cultural significance as a major source of fresh water in a region that was once rich with Hawaiian fishponds. The Maunalua Fishpond Heritage Center (MFHC) holds communal and cultural importance for the island of Hawaii. Prior to the non-profit organization’s involvement, Kanewai Springs and its surroundings were unoccupied between 1983 and 2007. In 2010, MFHC cleaned the overgrown site with the approval of the previous owners. In 2017, Kanewai Springs was purchased by MFHC and the Trust of Public Land, with the primary purpose of protecting and conserving its natural resources and preventing any activity that may pose a potential threat. The current site includes three vacant buildings, two residences, and a garage that are in a state of disrepair. The main building is in a state of great disrepair and requires short-term and long-term renovation. As illustrated in Figure 3, the roof is falling apart, and some rooms are beyond repair. In the short term, the existing structure needs to be made safe for the community to use, especially for educational purposes. Reconstructing the roof and ceiling while maximizing natural lighting and ventilation through existing windows will create a safer interior environment. The entire property also needs to be made ADA-compliant for accessibility. The ultimate goal is to restore the fishponds and the surrounding land.



**Figure 3.** Maunalua Fishpond Heritage Center. (a) Torn roof. (b) Exterior view of existing structure. (c) Existing fish pond. (d) Entry hall. (e) Broken interior space.

#### 4.2. Learning from the Vernacular/Native Hawaiian Architecture

Hawaiian vernacular architecture emerged from a fusion of Marquesan traditional construction techniques and Hawaii’s natural resources. The rectangular floor plan prevailed in Polynesian architecture, including in Hawaii, Fiji, Tahiti, New Zealand, and New Guinea. The hale, a multi-purpose structure serving as sleeping quarters, and a space for cooking, working, and worship, was constructed by the Marquesan settlers. Hale Heiau was a place of worship for Hawaiian gods such as Lono, Ku, and Madame Pele. Hale Mua was the sleeping ground for men, while Hale Noa was for the family. Hale Aina was where women ate, Hale Kahumu was where food was prepared, Hale Kua was where women worked on weaving mats, and Hale Wa’ā was where canoes were stored. Despite their different purposes, all hales shared the same foundation, structure, tools, and materials.

Hale, traditional Hawaiian structures, were constructed using locally sourced materials such as timber, rope, and leaves. Hardwood, including naio, uhiuhi, kauila, mamane, and koa (used more for canoes), were preferred for framing. Today, other hardwoods such as ironwood, kiawe, eucalyptus, strawberry guava, ohia, and mangrove are acceptable. Grass or leaves, such as pili or coconut leaves, were used for roofing and siding. Today, materials such as pili, kualohia, pueo, kawelu, sugarcane leaves, and ti leaves are acceptable. Coconut fiber was used for lashing structural members, with a minimum weight-carrying capacity of 400 pounds if used today. Cord used for floating purlins and thatched materials should withstand approximately 100 pounds, as per building code chapter 16.

#### 4.3. Design Proposal

The design concept is organized around the idea of “harmoniously interconnecting traditional Hawaiian vernacular architecture and the living spirit of the ‘aina’ (land)”. The design implements an organic, simple approach that utilizes only what is necessary and purposeful to guide the built space and the land. To achieve this, five design strategies are employed: (i) salvaging existing materials and using locally sourced materials, (ii) prioritizing natural lighting by placing larger openings, (iii) utilizing cross-ventilation and minimizing artificial cooling by placing large apertures across from one another, (iv) keeping the floorplan open by minimizing the use of fixed walls, and (v) implementing ADA accessibility throughout the space to ensure the inclusivity and engagement of all members in the community.

In addition, the design team worked closely with MFHC board members who represent the local Native Hawaiian community to ensure that not only were their needs met, but also to routinely collect their feedback on design proposals. The project was composed of several design phases, and at the end of each phase, board members were invited to provide feedback, comments, and suggestions. The design team also reached out to individual board members to conduct focused interviews. The end result was that the design concepts were directly derived from the input from board members and other community members. Furthermore, a Native Hawaiian designer was included in the design team, providing tremendous internal knowledge about Hawaiian culture and values. The final design is illustrated in Figure 4.



**Figure 4.** Final design proposal (image produced by Camry Pedro).

#### 5. Discussion

In Hawaii, the materials, techniques, and design reflected in the architecture mirrors social and culture change. Before 1778, there was a complex interrelationship between vernacular architecture and the isolated island environment; materials and tools came from the natural environment of the islands and were used to produce structures not only from the environment but to serve the social needs of the people who built them as well. The opportunity for technological change began in 1778–1779 when Cook brought large quantities of wood-working tools made of iron [37]. The corpus of indigenous knowledge pertaining to the conceptualization and construction of houses to harmonize with the environment, along with its concomitant cultural import, then underwent a precipitous decline. The cultural persistence of Hawaiian architecture lasted only until about 1920 [37]. Following the arrival of Europeans and Americans, new building materials and construction techniques were introduced, which coincided with the suppression of Native Hawaiian culture. As a result, the traditional Hawaiian architecture, along with its embedded vernacular knowledge, disappeared.

The case study presented in Section 4 demonstrates the renewal design framework that can be used as a tool to preserve indigenous culture. By studying the designs, materials,

and techniques used in vernacular and traditional buildings, people in Hawaii can gain a deeper understanding of the cultural, environmental, and social contexts in which they were created. The process of understanding, respecting, and accepting vernacular architecture and the associated heritage values is closely tied to recognizing and embracing a diverse range of identities. In interviews with local community members, our research team found that Hawaiian culture and vernacular architecture are not broadly taught or accessible to the next generation. This is a significant issue, as these are important parts of Hawaiian's history and identity. As one community member stated "In my opinion, the biggest barrier would be the lack of teachers and the lack of excitement about learning from younger generations. People typically don't grow up learning or seeing Hawaiian culture present on a day to day basis and therefore don't have a big of a desire to learn and to teach down the road". In such a context, buildings and the built environment might be the first place to try. A built environment that incorporates vernacular knowledge can create a physical space that embodies and preserves indigenous culture. Such an immersive environment provides day-to-day experiences for both native Hawaiian and non-Native individuals interested in learning about and preserving Hawaiian indigenous culture.

## 6. Conclusions

Indigenous knowledge was built up over generations by culturally distinct people living in a close relationship with natural ecosystems, the land, plants, water and animals, etc. Different from mainstream Western scientific knowledge, indigenous knowledge is context-specific to a community and place; consequently, the vernacular architecture that embodies the indigenous knowledge is culturally specific and integrated with regard to a particular "place" towards the goal of sustainability. Indigenous knowledge of vernacular architecture is derived using the same method as modern Western science [42]; the distinction is that vernacular architecture operates from a "high-context view", including all relational connections in its consideration, while modern Western sustainable building practices comes from a "low-context" view, often reducing sustainability to energy performance, water conservation, and other quantified measures [46].

The inclusion of vernacular-architecture-embodied indigenous knowledge is a relatively new and radical idea for modern sustainable design practice that has not been given sufficient attention. In this paper, we proposed using vernacular architecture as a vehicle to preserve the overall diversity of human knowledge related to the natural ecosystem as a way to build a sustainable future, while preserving cultural diversity. With this proposed framework, the hope is that such an integrated approach can be applied to other places to build climate resilience and preserve indigenous knowledge and culture.

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