

Hybrid Methodologies for Documenting Endangered Wooden Architecture, Preserving Knowledge and Enabling Continuity of Traditions: Insights from Indonesia

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Abstract

Documentation of endangered wooden architecture requires methodological frameworks that balance precision, cultural sensitivity, and long-term preservation goals. Vernacular architecture, however, extends beyond material vulnerability: it reflects a living dialogue between people, place, and cultural practice. In the Kamanasa region of West Timor, this dialogue appears in clan-based settlement patterns, symbolic spatial organization, and wooden stilt houses that embody cosmological and social relationships. As modernization reshapes rural environments and traditional construction knowledge recedes, documenting vernacular architecture becomes essential—not simply to preserve physical forms, but to sustain the knowledge systems that give them meaning.

This study applies a hybrid documentation workflow in the village of Manlima that integrates three complementary approaches: LiDAR-based scanning using an iPad Pro with Polycam Pro (substituting for an intended Leica BLK360), drone-based photogrammetry, and hand-measured drawings conducted collaboratively with the community members. These methods were deployed simultaneously to capture structural geometry, spatial context, material articulation, and cultural interpretation. Datasets were aligned and synthesized within a unified spatial register, creating a multi-layered representation of the settlement and its architectural logic.

The hybrid methodology revealed the coherence of Kamanasa vernacular architecture across structural, spatial, and symbolic dimensions. Digital scans clarified the organizational logic of the “house-as-cosmos,” while aerial imagery illuminated settlement orientation and ritual anchoring. Hand-measured drawings enriched these datasets with cultural insight and local interpretation. Together, these methods produced a record that is

technically rigorous yet culturally grounded, demonstrating that documentation can function not only as a conservation tool but also as a framework for supporting the continuity of vernacular knowledge and informing culturally rooted design adaptations.

Keywords: Vernacular settlements; Wooden architecture; Hybrid documentation; Laser scanning; Photogrammetry; Hand measurement; Digital heritage; Kamanasa; Timor; Community-engaged conservation.

Introduction

Vernacular settlements across the island of Timor embody complex relationships between social identity, cosmological belief, and environmental adaptation. In Kamanasa, these relationships are expressed through the clustering of clan houses, the orientation of dwellings towards sacred ancestral structures, and the use of symbolic wooden elements such as male and female posts. These spatial patterns and construction practices form a cultural logic that extends far beyond their material manifestations.

As pressures of modernization and changing livelihoods alter building patterns, there is an urgent need to document both the tangible structures and the intangible systems of knowledge that sustain them. This paper presents a hybrid documentation methodology implemented in Manlima Village, West Timor, designed to record vernacular architecture in a way that respects its cultural, symbolic, and spatial dimensions. By integrating digital and analog tools, the workflow seeks to bridge technical precision with community knowledge, offering a foundation for both conservation and future design adaptation.

The Context: Manlima and the Vernacular Landscape of Kamanasa

The village of Manlima sits within the Kamanasa area of Malaka Regency, approximately 3.5 kilometers from the town of Betun. Historically, the Kamanasa community occupied territory near the present-day Suai in Timor-Leste. Following the conflict in 1911, the community relocated westward, transporting their houses and ritual elements—most notably a sacred banyan sapling—using a sophisticated mortise-and-tenon system that allowed structures to be dismantled and rebuilt.

Today, the social and spatial organization of the village remains deeply shaped by this history. Each clan maintains a sacred house (Uma Kain), and family dwellings orient themselves towards these structures according to longstanding spatial ethics that prohibit turning one's back to ancestral authority. A collective sacred house, the Uma Raja, serves as a focal point for the village-wide rituals, reinforcing unity among the clans.

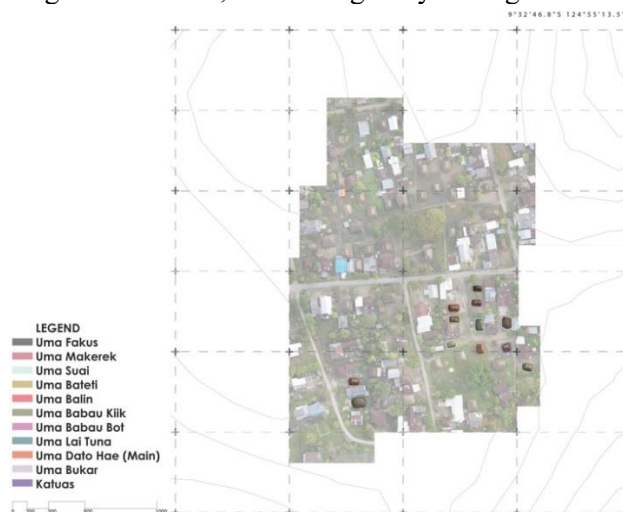


Fig. 1: Drone-based site plan illustrating the proximity of clan clusters within the Kamanasa settlement. The documented B-2 house type is referred to as 'Katuas.'

Source: Authors

These traditions coexist with more recent influences: Catholicism introduced in the early 20th century and the growing presence of concrete houses along the primary roads. Yet within the clan compounds, vernacular forms persist as vital repositories of identity, memory, and cosmological meaning.

Vernacular Architecture: Form, Meaning, and Ecology

Kamanasa houses articulate complex relationships between cosmology, gender, social hierarchy, and ecological adaptation. The dominant built form consists of a low, four-sloped roof set atop a raised timber platform. Two symbolic posts—male at the front and female at the rear—anchor the structure both physically and conceptually. Interior spaces are organized into gendered domains, ritual zones, and areas for receiving guests, all of which follow established protocols of movement, seating, and hierarchy.

Vertically, the house represents a tripartite cosmos: sacred heirlooms stored in the attic above, domestic life at mid-level, and livestock sheltered in the undercroft below. Horizontally, porches and terraces facilitate social interactions while woven *gewang* panels (woven palm leaf mats) provide flexible shading and privacy.

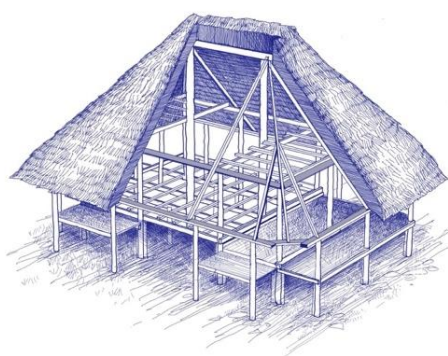


Fig. 2: 3D Section of a traditional Kamanasa house illustrating its cosmological organization.
Source: Drawing by Tjokorda Gede Dalem Suparsa

As shown in the above image, the tripartite vertical structure—attic, living space, and undercroft—embodies sacred, domestic, and ecological realms, while the front terrace functions as a social threshold for host–guest interactions. These architectural elements reveal a sophisticated relationship between the environment, culture, and craft—one that documentations must capture through both measurements and interpretations.

Doctrinal Grounding for Documentation

The hybrid documentation approach used in this study aligns with key international principles that guide the recording and preservation of cultural heritage. The Venice Charter (1964) emphasizes that conservation must draw upon “all the sciences and techniques” appropriate to understanding a site. Although originally written for monuments, its broader call for rigorous, evidence-based documentation provides an important foundation for recording vernacular settlements such as those in Kamanasa.

The ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites (1996) further stress that documentation should capture not only physical forms but also setting, use, and the meanings. These principles encourage the integration of multiple sources of information and highlight the importance of transparency, accuracy, and long-term accessibility. This directly supports the combined use of digital scanning, photogrammetry, and hand-measured drawings adopted in the project.

The mission of the CIPA Heritage Documentation reinforces this approach by acknowledging that responsible documentation may employ a variety of tools—from high-end scanners to more accessible devices—so long as methods remain consistent, clear, and suited to the cultural context. This flexibility validates the use of the iPad Pro LiDAR system when the intended Leica BLK360 is unavailable.

Finally, the UNESCO Charter on the Preservation of Digital Heritage (2003) frames digital datasets as a form of heritage that must be curated, stored, and shared with care. This principle informs the commitment of the project to open formats, structured metadata, and community-oriented dissemination.

Taken together, these doctrinal frameworks provide a concise but meaningful justification for the hybrid methodology, ensuring that it is both technically grounded and culturally sensitive.

The integration of these three modes of documentation—LiDAR scanning, photogrammetry, and analog drawing—occurred during the processing and interpretive analysis. LiDAR-generated point clouds were aligned with the drone-derived surface model using shared reference points, allowing the datasets to be visualized within a unified spatial register. Hand drawings were then situated within this digital structure, either through georeferencing or by aligning them with orthographic projections and section cuts extracted from the point cloud. This hybrid record combines geometric accuracy, environmental context, and cultural interpretation, yielding a comprehensive representation that speaks to both the tangible and intangible aspects of the Kamanasa vernacular landscape.

This approach aligns closely with international doctrinal standards for heritage documentation, including ICOMOS and CIPA principles that emphasize the use of all relevant sciences and techniques, as well as UNESCO's charter on digital heritage stewardship. More importantly, it responds to the community needs by generating documentation that is technically rigorous yet accessible to the local residents, educators, designers, and policymakers. The hybrid workflow demonstrates that a culturally responsive documentation strategy must embrace multiple ways of seeing—digital, analog, and experiential—if it is to sustain the knowledge systems that underpin vernacular architecture.



Fig. 3: Comparison of the raw LiDAR scan captured on site using Polycam Pro (left) and the refined model created after processing and alignment with photogrammetric data (right).

The raw scan reflects the immediacy and flexibility of field acquisition, while the processed model highlights the structural clarity, spatial relationships, and analytic interpretability. Together, they illustrate the multi-stage workflow central to the hybrid documentation methodology.

Application: The Uma Raja and Clan House Cluster

The hybrid documentation workflow was applied to a representative cluster in the village of Manlima, consisting of the Uma Raja (the collective sacred house of the village), the clan sacred house (Uma Kain), and two residential structures in different stages of use and repair. Together, these buildings form a microcosm of Kamanasa spatial organization and embody the layered relationships between lineage, ritual practice, and everyday life. Their arrangement around the sacred banyan tree, which anchors both cosmological identity and historical memory, further reinforces their importance as a focal point for the study.

The spatial composition of the cluster reflects principles that guide the settlement layout across Kamanasa. The dwellings face toward their respective sacred houses,

maintaining a spatial ethic that prohibits turning one's back on ancestral authority. This orientation, visible in both the LiDAR scans and the drone orthomosaic, produces a subtle but deliberate geometry that ties domestic life to ritual structures.

The banyan tree provides an additional axis of meaning: as a living symbol transplanted from the place of origin of the community during their early 20th century displacement, and continues to serve as a material link to the past. Its expansive canopy and the position at the center of the compound are clearly legible in the aerial imagery, which helped situate each house within a relational, and not merely physical, landscape.

The LiDAR scans captured the volumetric and structural distinctiveness of the houses, including the interplay between the symbolic male and female posts, the asymmetry of the front terrace, and the complex bracing that supports the low-sloping roof. When examined in section, the scans revealed the nuanced spatial hierarchy of the interiors—the elevated hearth, the gendered zones, and the vertical differentiation between the attic, middle, and undercroft levels. These geometric insights were then enriched by the hand-measured drawings, in which elders helped identify the ritual functions of certain spaces, the meanings associated with the joinery types, and the social protocols embedded in the thresholds and the seating levels.

In this way, the application demonstrated how the hybrid workflow allows the vernacular buildings to be read simultaneously as technical artifacts, cultural narratives, and spatial manifestations of social structure. Rather than separating material information from the intangible practices, the documentation process brought them into dialogue, producing a multi-layered understanding of the cluster that would not be possible through any single method alone.



Fig. 4: Interior views of a traditional Kamanasa house (B2).

Source: Authors

The first image shown above (Fig. 4) highlights the structural system—posts, rafters, and woven wall panels—revealing the craftsmanship and spatial logic of vernacular construction. The second image shows the cooking area, a culturally significant domestic zone associated with nourishment, ritual practice, and intergenerational knowledge. Together, the images illustrate how material structure and everyday life intertwine within the architectural fabric of the house.

Findings: Insights from Hybrid Documentation

One of the most significant outcomes of the hybrid workflow is the degree to which it illuminated the coherence of the Kamanasa “house-as-cosmos” model. The LiDAR-based scans made visible the precise vertical organization of the buildings, confirming the tripartite division between the sacred storage above, domestic life at the mid-level, and the animals sheltered below. These spatial hierarchies, long described in ethnographic literature, took on a new clarity when rendered through digital sections and spatial slices. The photogrammetric model extended this understanding across the settlement, revealing how domestic, ritual, and vegetative elements cooperate to structure the lived environment.

Another important finding is concerned with the phenomenon of continuity within change. Although many families have begun constructing concrete or block houses along the main road, vernacular houses within the clan compounds continue to embody the principles of orientation, spatial ethics, and symbolic duality that define Kamanasa identity. The digital documentation helped clarify this distinction by showing how the traditional houses respond to the environmental conditions and the social practices in ways that modern structures do not—particularly in their use of raised floors, shaded terraces, and porous woven enclosures, do. These insights suggest that the erosion of vernacular architecture is not solely a material problem, but a transformation in the knowledge system that governs the spatial and symbolic relationships.

The combination of digital and analog methods also revealed the value of community participation in the interpretive process. Because the hand-measured drawings encouraged storytelling and explanations, it provided a counterbalance to the abstracted precision of digital data. In several instances, accounts of elders corrected or contextualized features observed in the scans—for example, why specific posts tilt slightly or why certain spaces remain intentionally narrow or dim. This interplay underscored that vernacular architecture should not be understood only through its physical form, but also through the social obligations and ritual narratives that shape its construction and use.

Finally, the workflow demonstrated that accessible digital tools, including consumer grade LiDAR systems such as Polycam, can meaningfully contribute to the documentation of vernacular sites when paired with photogrammetry and hand-measured drawings. Although these tools do not provide the precision of professional scanners, their flexibility, mobility, and ability to engage community participants make them valuable components of a broader methodological repertoire.

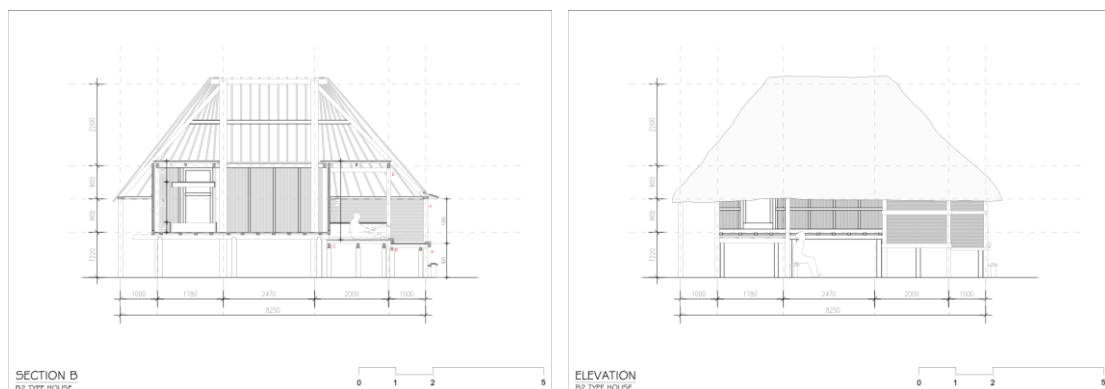


Fig. 5: Section and elevation drawings of House B2 derived from integrated LiDAR scans, drone photogrammetry, and hand-measured data. The drawings illustrate the vertical tripartition characteristic of the Kamanasa “house-as-cosmos” model.

Source: Authors

Discussion

This exercise demonstrates documentation as a framework for continuity of vernacular as illustrated through the case study. The outcome of the project suggests that documentation should not be understood as a static record of disappearing traditions, but as a framework through which vernacular knowledge can persist, evolve, and inform contemporary design practice. In the case of Kamanasa, the hybrid methodology created opportunities to consider how the traditional principles—orientation to sacred houses, symbolic duality of posts, and the integration of domestic, ecological, and ritual functions—might be adapted within the modern building materials or construction constraints.

This insight positions documentation as an intermediary step between the past and the future: a means of distilling the logic of vernacular design so that it may be reinterpreted rather than replicated. Such reinterpretation is essential in contexts where traditional timber resources are scarce or where families prefer the perceived durability and prestige of modern construction. The hybrid workflow provides the analytic clarity needed to translate vernacular concepts into contemporary architectural strategies without reducing them to decorative motifs or superficial formal gestures.

At the same time, the project highlights the pedagogical significance of documentation. When digital scans, drawings, and annotated models are shared with the students, youth groups, and community leaders, they offer tools for teaching construction principles, environmental adaptation, and cultural values embedded in space. It is fair to claim that this educational dimension strengthens the community agency and supports the creation of design pathways rooted in vernacular heritage rather than external commercial influences.

In this way, documentation becomes a means of articulating local identity within a rapidly shifting built environment. It affirms that vernacular architecture remains relevant—not simply because it is preserved unchanged, but because its principles continue to guide spatial and social life when translated into new forms.

Conclusions

This documentation of vernacular architecture in Kamanasa demonstrates the value of a hybrid methodology that integrates digital precision with analog interpretations and community engagements. By combining LiDAR scanning, photogrammetry, and hand measured drawings, the study produced a comprehensive record that captures both the technical and cultural dimensions of the architectural heritage of the village. The approach revealed the structural logic, spatial ethics, and symbolic systems that shape Kamanasa houses, while also highlighting the adaptability of these traditions within the contemporary conditions.

More than a technical achievement, the documentation process reaffirmed the importance of vernacular knowledge as a living system that continues to inform identity, social relationships, and environmental adaptation. The future of vernacular heritage, therefore, depends not only on preserving structures but on sustaining the knowledge frameworks that animate them. A hybrid documentation workflow supports this continuity by making vernacular principles legible, transferable, and relevant to the present and future generations.

Equally significant, these methodologies offer powerful educational opportunities. Integrating hybrid documentation into architectural curricula—through fieldwork, digital modeling, and community collaboration—can cultivate greater cultural awareness and respect for the vernacular settlements. When students engage directly with the traditional environments, they learn that design is not only about form and technology but also about empathy, continuity, and stewardship. In this sense, hybrid documentation becomes not only a preservation tool but also a pedagogical framework for teaching cultural humility, sustainable design thinking, and respect for place-based knowledge in architectural education

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Ethical Practice: This research followed accepted ethical practices. It did not involve any personal data, nor did it coerce any participants to take part in this research under pressure.

Availability of Data: Data presented in this research is selected from a larger data set and they are available for scrutiny by any legitimate organization.

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