

Mountain-Born Architecture: The Lung Vai School in Vietnam

Ar. Kiranjeet Kaur Jassal^{1*}, Ajay Kumar²

Abstract

Lung Vai School, located in the mountainous Minh Tân region of northern Vietnam, represents a context-sensitive architectural response shaped by geography, climate, and the cultural traditions of the Hmong community. Designed by 1+1>2 Architects and completed in 2020, the school demonstrates how educational infrastructure in remote regions can be realized through vernacular intelligence, material ecology, and participatory construction processes. Rather than relying on imported typologies or industrialized systems, the project draws directly from local terrain, building practices, and social patterns to create an environment that is both resilient and culturally meaningful. This study examines Lung Vai School through an integrated framework that includes site responsiveness, material selection, spatial organization, environmental performance, and social impact. Rammed earth walls constructed from on-site soil provide thermal stability and visual continuity with the surrounding mountains. Bamboo lattice trusses reinterpret traditional craft while enabling lightweight structural spans. Semi-transparent polycarbonate roofing introduces diffused daylight, reduces energy demand, and responds sensitively to the region's mist-heavy climate. Decentralized water harvesting, biological wastewater treatment, and small-scale solar systems further reinforce the project's self-sufficiency. Beyond technical performance, the school functions as a social catalyst. Community participation in construction strengthened local ownership and transferred building knowledge across generations. Spatial layouts inspired by terraced settlements support child-friendly movement, outdoor learning, and collective gathering. Through these strategies, Lung Vai School transcends its role as a functional facility and becomes a spatial extension of Hmong cultural life. The findings position the project as a replicable model for rural educational architecture in mountainous and resource-constrained regions. It demonstrates that sustainable design can emerge from local materials, cultural continuity, and environmental logic, offering an alternative to standardized rural infrastructure across Southeast Asia and similar contexts.

Keywords: Bamboo structure, community participation, environmental architecture, Hmong community, Lung Vai School, passive cooling, rammed earth construction, rural education architecture, sustainable design, vernacular architecture

INTRODUCTION

Educational architecture in remote and mountainous regions faces a complex convergence of environmental, infrastructural, and socio-cultural challenges. In northern Vietnam, ethnic minority communities, such as the Hmong, inhabit steep terrains shaped by monsoon cycles, fragile access routes, and limited state infrastructure. In these settings, architecture cannot rely on conventional construction models that assume mechanized access, stable utilities, or standardized materials [1]. Instead, buildings must respond directly to land, climate, and community practices.

The Hmong village of Minh Tân exemplifies these conditions. Daily life is structured around subsistence agriculture, seasonal rhythms, and foot-based mobility across terraced slopes. Prior to the construction of Lung Vai School, early childhood

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education was conducted in makeshift timber classrooms that offered minimal protection from rain, cold, or heat. Poor ventilation, low daylight levels, and structural deterioration led to inconsistent attendance and undermined the learning environment. More critically, these structures lacked cultural relevance and failed to reflect the identity of the community they served [2].

Lung Vai School emerged as a deliberate departure from such generic solutions. Designed by 1+1>2 Architects, the project was guided by a fundamental question: how can architecture emerge from its landscape rather than be imposed upon it? The design process prioritized vernacular logic, material availability, and participatory construction over visual formalism. Instead of flattening the site, the building follows natural contours. Instead of imported materials, it relies on earth and bamboo sourced from nearby slopes. Instead of external contractors, local villagers became active collaborators in the construction process [3].

This approach positions the school as both a physical and social structure. Architecturally, it responds to environmental constraints through passive thermal regulation, natural ventilation, and daylight optimization. Spatially, it reflects settlement patterns familiar to the Hmong, with clustered forms, curved circulation paths, and communal outdoor spaces. Socially, it strengthens collective identity by embedding cultural references into form, craft, and construction techniques [4].

The significance of Lung Vai School extends beyond its immediate context. Across Southeast Asia, rural educational infrastructure often relies on standardized designs that neglect climate, culture, and long-term maintenance. Such models frequently result in buildings that age poorly and fail to gain community acceptance. Lung Vai School offers an alternative paradigm, demonstrating that meaningful educational spaces can be created through low-tech, context-driven strategies (Figure 1) [5].



Figure 1. Aerial site context showing Lung Vai School embedded into mountain terrain.

This article investigates the project as an example of architecture that integrates environmental intelligence with cultural continuity. By examining its design intent, material systems, spatial organization, and community engagement, the study aims to contribute to broader discussions on sustainable rural architecture and socially embedded design practices [6].

LITERATURE STUDY

Scholarly discourse on vernacular architecture and sustainable rural development emphasizes the value of locally adapted building practices shaped by climate, materials, and cultural traditions. Paul Oliver's foundational work on vernacular architecture highlights how indigenous construction systems evolve through long-term environmental negotiation rather than formal design theory. Such systems often demonstrate high environmental efficiency, material economy, and cultural coherence, particularly in resource-constrained settings.

In Southeast Asia, research on mountainous architecture underscores the importance of terrain-responsive forms and passive environmental strategies. Nguyen and Tran identify that highland settlements frequently employ compact massing, earth-based construction, and elevated roofs to address humidity, rainfall, and temperature fluctuations. These strategies reduce dependence on mechanical systems while enhancing indoor comfort. Rammed earth construction, in particular, has gained renewed academic attention for its low embodied energy, thermal mass, and durability when stabilized appropriately [7].

Studies on community participation in construction further reveal its social and environmental benefits. Hao's research on rural Vietnamese building practices demonstrates that participatory construction not only reduces costs and emissions but also fosters a sense of ownership and long-term stewardship. When communities are involved in material preparation and assembly, buildings are more likely to be maintained, adapted, and respected over time.

Bamboo has also been widely studied as a sustainable structural material in tropical regions. Its high tensile strength, rapid renewability, and familiarity among local builders make it suitable for lightweight frameworks and roof systems. Research by Vo on polycarbonate roofing systems in humid climates shows that semi-transparent materials can effectively balance daylighting and weather protection when combined with appropriate ventilation strategies [8].

Educational architecture literature increasingly recognizes the relationship between learning environments and spatial quality. Tran's work on schools for ethnic minority communities in Vietnam emphasizes that culturally responsive spaces improve attendance, engagement, and emotional well-being. Circular layouts, outdoor learning areas, and visual connections to nature are shown to support collaborative learning and reduce psychological stress among children.

Despite this growing body of research, many rural school projects continue to rely on standardized construction templates. These models often disregard local climate, materials, and cultural patterns, resulting in buildings that are inefficient and socially disconnected. Lung Vai School aligns closely with the principles outlined in vernacular and sustainability literature while translating them into a contemporary architectural language [9].

By synthesizing insights from material studies, participatory design research, and educational space theory, this paper situates Lung Vai School within a broader academic framework. The project exemplifies how vernacular knowledge can inform modern architectural practice without romanticizing tradition or rejecting innovation.

CONTEXT AND COMMUNITY

The Hmong community of Minh Tân depends largely on subsistence agriculture, small livestock rearing, and ancestral craft traditions. Geography shapes everyday life: steep slopes require terraced farming; monsoon seasons dictate labour schedules; and remote location results in limited access to government services, including education.

The previous school facility consisted of fragile timber structures lacking insulation, ventilation, and weather protection. Many families kept children at home during harsh weather, leading to inconsistent attendance. The new Lung Vai School was, therefore, conceived as an educational anchor point capable of withstanding mountain climate while reflecting the community's cultural values [10].

A key challenge was site accessibility. Narrow footpaths, uneven terrain, and the absence of motorable roads meant that trucks and cranes could not reach the location. Responding to this constraint, 1+1>2 Architects collaborated directly with villagers. Residents hand-carried stones, earth, and bamboo from nearby slopes. This not only reduced transportation emissions but reinforced community ownership over the project (Figure 2).

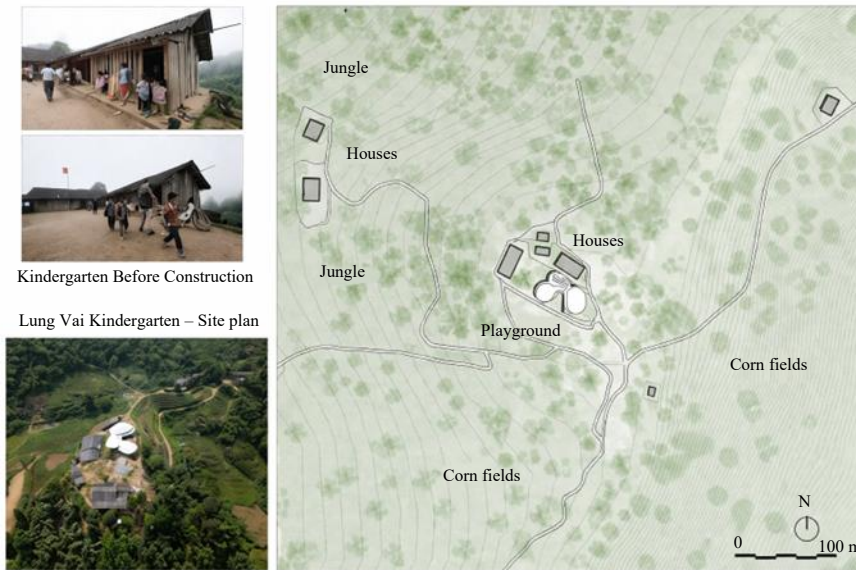


Figure 2. Pre-construction timber classrooms and site plan illustrating terrain and settlement pattern.

The design also drew from the settlement pattern of scattered homes along terraced fields. Circulation is guided by footpaths carved into the soil; these informed the building's curved and interconnected form. By aligning with these routes, the school maintains continuity with the village's spatial logic.

DESIGN INTENT AND FORM DEVELOPMENT

The conceptual foundation of the project was guided by a simple but profound inquiry:

How Can a Building Feel as Though It Grew from the Mountain Itself?

To answer this, the architects began by studying regional vernacular structures circular livestock pens, drying yards, domestic compounds, and ceremonial spaces. Circular and ovoid forms were found to sit naturally within steep landscapes, requiring minimal excavation while offering strong wind resistance.

Three Primary Volumes Emerged

- An elementary classroom.
- Two kindergarten rooms.
- All linked by a sinuous outdoor walkway.

The circulation path resembles a contour line, winding gently across the site without disrupting the natural slope. This gradual movement creates a sense of journey, suitable for children's daily transitions (Figure 3).

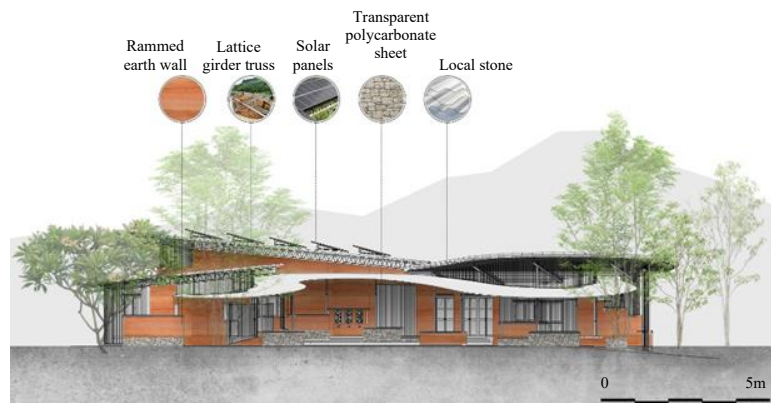


Figure 3. Sectional view highlighting key materials used in Lung Vai School.

The roof geometry developed through multiple rounds of sketching and modelling. The final form – a layered canopy of curved polycarbonate sheets supported by bamboo and steel trusses appears to hover above the heavy rammed earth walls. The aesthetic evokes forest mushrooms emerging after rain, tying the architecture visually to local ecology.

CONSTRUCTION LOGIC AND MATERIAL ECOLOGY

Material choices were guided by three principles:

- Minimize transportation.
- Maximize local material knowledge.
- Enhance environmental performance.

Rammed Earth Walls

Rammed earth forms the primary structural system. Soil from the site was mixed with small amounts of cement for stability, then compacted into formwork. The resulting walls exhibit layered coloration, echoing the mountain's natural stratification. Benefits include.

- High thermal mass.
- Reduced carbon footprint.
- Long-term durability.
- Cultural resonance with Hmong earth-based crafts.

Bamboo and Steel Lattice Trusses

The lightweight roof structure uses bamboo poles arranged in lattices and supported by steel connectors. Bamboo is familiar to local builders, flexible under stress, and easily replaceable. The lattice system creates a structural transparency that contrasts with the solidity of the earth walls.

Polycarbonate Roofing

Semi-transparent polycarbonate sheets serve as the main roofing element. Their diffused daylight softens interior brightness and eliminates the need for artificial lighting during daytime. The translucent quality responds to the mountain environment, where clouds and mist often blanket the region (Figure 4).

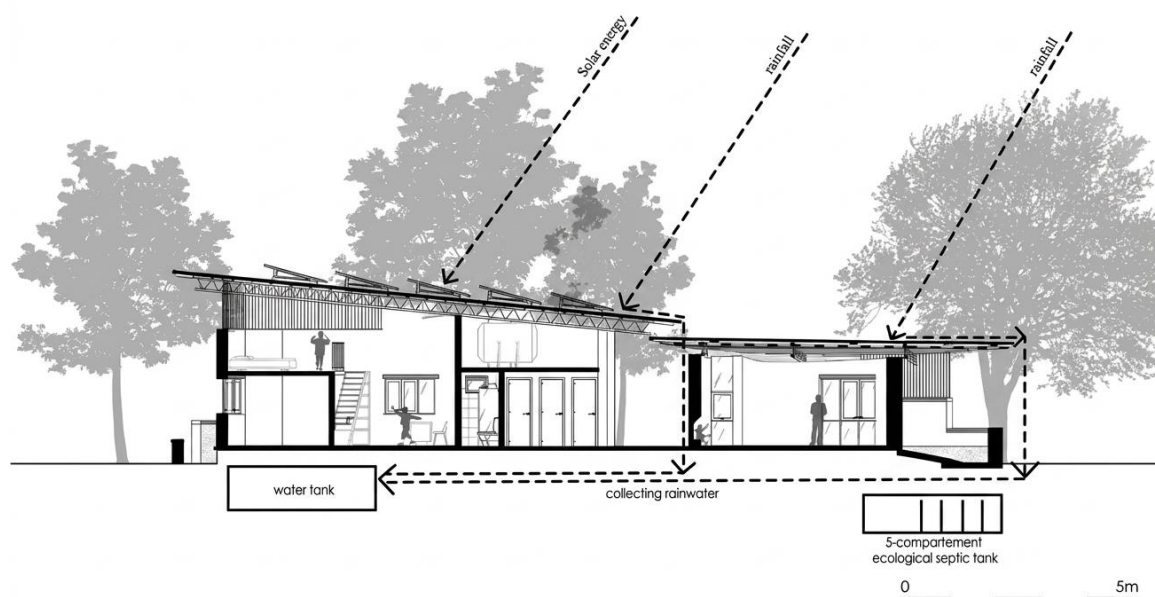


Figure 4. Sectional diagrams showing solar gain, rainwater collection, and water tank system.

Water and Energy Systems

Given limited infrastructure, the school integrates autonomous environmental systems:

- Solar panels generate basic electrical supply.
- Curved roofs channel rainwater into storage tanks for cleaning and irrigation.
- A biological, multi-chamber septic system filters wastewater for landscape reuse.

These systems reduce environmental impact while empowering the community with low-maintenance solutions.

SPATIAL ORGANIZATION

The building is organized into three main learning spaces, each with distinct form and function.

- *Kindergarten Cluster*: Two ovoid classrooms overlap at a shared outdoor play corridor. This arrangement supports free movement and fosters interaction among younger students. Seating is arranged in circular patterns that encourage collaborative learning.
- *Elementary Classroom*: The largest volume, placed slightly higher on the slope, accommodates older students. A continuous window band frames panoramic mountain views, reducing visual enclosure and connecting children to nature (Figure 5).
- *Teacher's Room, Kitchen & Sanitation*: Support spaces are compact but centrally located for operational efficiency.
- *School Yard*: A gently carved earth bowl at the centre acts as a communal gathering space for festivals, play, and storytelling.

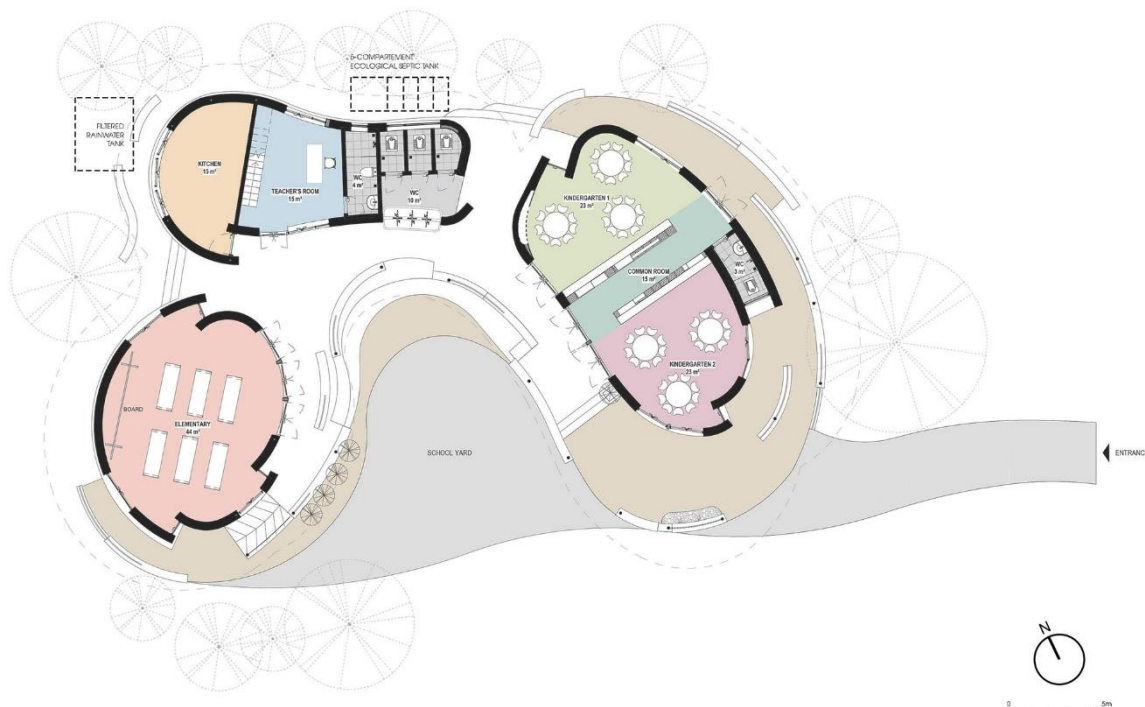


Figure 5. Floor plan illustrating spatial organization of kindergarten, elementary, and support spaces.

ENVIRONMENTAL STRATEGIES

Lung Vai School leverages passive techniques to respond to extreme mountain climate.

Thermal Comfort

Rammed earth walls regulate fluctuating temperatures by storing heat during the day and releasing it slowly at night. This stabilizes interior conditions through both humid summers and cold winters.

Daylighting

Polycarbonate roof bands diffuse sunlight, creating soft illumination. Bamboo ceiling strips filter this light further, producing dynamic patterns that mimic forest shade an effect known to reduce glare and improve comfort in learning environments (Figure 6).



Figure 6. Interior view of classroom showing polycarbonate daylight band and bamboo ceiling.

Natural Ventilation

Openings along the downslope façade draw in cooler valley breezes, while vents near the roof allow warm air to escape, establishing continuous cross-ventilation.

Water Harvesting and Treatment

Curved roofs maximize rainwater capture, which is essential in regions where water supply is inconsistent. The biological septic system ensures that wastewater is treated before re-entering the landscape.

CULTURAL MEANING AND SOCIAL AGENCY

The architecture embodies Hmong cultural expression through form, materiality, and construction processes. Circular forms reference ancestral settlement patterns. Bamboo latticework recalls local basketry. Rammed earth walls revive traditional building practices that have diminished due to modernization (Figure 7).



Figure 7. Rammed earth circulation spaces and sheltered walkways.

Perhaps most significant is the role of community participation. Villagers acted not just as labourers but as co-creators. Their involvement in mixing soil, ramming earth, carrying materials, and assembling bamboo structures forged a collective sense of ownership. This participatory process transformed the school from a donated object into a community achievement.

DISCUSSION

Lung Vai School illustrates how architecture in remote regions can transcend functional provision and operate as a socially embedded and environmentally responsive system. Unlike standardized rural schools that prioritize speed and cost over context, this project demonstrates the value of slow, place-driven design processes. Each architectural decision from material choice to spatial layout responds directly to the realities of mountain life and Hmong cultural practices.

One of the project's most significant contributions lies in its material strategy. Rammed earth, bamboo, and polycarbonate are not treated as aesthetic gestures but as functional components working in climatic and structural balance. The heavy thermal mass of earth walls stabilizes interior temperatures, while lightweight bamboo trusses reduce structural loads on steep terrain. Polycarbonate roofing addresses daylight scarcity caused by frequent mist and cloud cover without introducing glare or overheating.

Equally important is the project's participatory construction model. Community involvement transformed logistical constraints into opportunities for social engagement. The act of building became a collective process of knowledge exchange, reinforcing cultural continuity and local agency. This approach challenges the conventional separation between architect, builder, and user.

From an educational perspective, the school's spatial organization supports both formal learning and informal social interaction. Curved circulation paths shared outdoor spaces, and visual connections to the landscape encourage exploration and movement, particularly important for early childhood education. The architecture fosters a sense of belonging rather than institutional discipline.

The project also advances discussions on material circularity and adaptability. Components can be repaired or replaced using local resources, ensuring long-term resilience in regions with fragile supply chains. As such, Lung Vai School offers a compelling model for future rural infrastructure that balances environmental performance, cultural identity, and social sustainability.

CONCLUSION

Lung Vai School stands as a clear example of architecture shaped by land, culture, and collective effort. Rather than imposing an external educational model onto a remote mountain village, the project grows from the environmental and social conditions of Minh Tân. Through the use of rammed earth, bamboo, and lightweight roofing systems, the building achieves climatic comfort while maintaining material honesty and cultural relevance.

The school's success lies not only in its technical performance but in its social resonance. Community participation in construction fostered ownership, skill sharing, and long-term stewardship. Architectural forms derived from local settlement patterns and craft traditions reinforce cultural continuity while supporting contemporary educational needs. This balance between tradition and innovation allows the building to function as both a learning space and a community landmark.

In a broader context, Lung Vai School challenges prevailing approaches to rural educational infrastructure that prioritize standardization over specificity. It demonstrates that sustainable architecture does not require advanced technology or imported materials but rather careful observation, environmental intelligence, and respect for local knowledge. The project offers a replicable framework for other mountainous and resource-limited regions facing similar challenges.

As climate uncertainty, resource constraints, and social inequality continue to shape the future of rural development, projects, such as Lung Vai School, provide valuable lessons. They remind architects and planners that meaningful sustainability emerges from empathy, participation, and contextual design. In this sense, Lung Vai School is not merely a building, but a living architectural narrative rooted in the mountains and the people who inhabit them.

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