Building for climate resilience

Cases of good practices and solutions for safe and resilient settlements in the Hindu Kush Himalaya

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Message from the Director General, ICIMOD

The Hindu Kush Himalaya (HKH) region is among the most vulnerable regions to the triple planetary crises of biodiversity loss, climate change, and pollution. Rapid urbanisation along with other socioeconomic changes is exacerbating the region's exposure to the crises.

This rapid, poorly planned, and haphazard urbanisation, predominated by the construction of steel and concrete structures, including high-rises, not only spoils the natural beauty of mountain environments but also has long-term implications to our fragile landscapes. This has increased hazard exposure and vulnerabilities across the region. The challenge before us is clear. The preservation of mountain environments needs to be carefully balanced with the development aspirations of mountain communities under fast-changing climate and socioeconomic scenarios, so that the mountain settlements are safe, liveable and sustainable.

There exists no single solution to these complex challenges, but there are valuable lessons to be learned from the many science-based approaches, traditional practices, innovative technologies, and collaborative governance models that have been tried and tested in the diverse contexts of the HKH. These lessons can be adapted to address local needs and challenges, while promoting sustainable and resilient development.

This collection of cases on sustainable and resilient buildings/housing in the HKH brings together approaches that support safer and more climate resilient settlements. Policies and technologies must support the planning and construction of mountain settlements that are more resistant to disasters, aesthetically pleasant and blend with the natural landscapes. This would also call for the use of locally available construction materials and traditional skills and expertise, while incorporating modern amenities like proper sanitation, insulation and ventilation facilities.

This collection of cases is a testimony of how progress and innovation is possible even in a region facing many complex challenges. I hope that it will inspire and motivate policymakers, practitioners, and communities to create a sustainable future for mountain settlements. The HKH region can build safer homes, protect its cultural heritage, and prepare for a rapidly changing climate. We can create greener, risk-sensitive and pro-poor settlements that respect both people and nature.

Pema Gyamtsho
Director General, ICIMOD

Acronyms and abbreviations

BNBC	Bangladesh National Building Code
BUN	Build Up Nepal
CBFT	Cement Bamboo Frame Technology
CGI	Corrugated Galvanised Iron
CHT	Chittagong Hill Tracts
CSEB	Compressed Stabilised Earth Blocks
CRS	Catholic Relief Services
CRSDP	Climate Resilient Settlement Development
GESI	Gender Equality and Social Inclusion
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood
GNH	Gross National Happiness
HKH	Hindu Kush Himalaya
HUC	Himalayan University Consortium
ICIMOD	International Centre for Integrated Mountain Development
LSS	Lime Stabilised Soil
NPO	Non-profit organisation
RCC	Reinforced Cement Concrete
RICS	Royal Institution of Chartered Surveyors
RS	Remote Sensing
SHRRP	Sindh Housing Recovery and Reconstruction Platform

Content

Executive Summary

The Hindu Kush Himalaya (HKH) region, stretching 3,500 kilometres across eight countries -Afghanistan, Bhutan, Bangladesh, China, India, Myanmar, Nepal, and Pakistan - is an asset of global significance. It exhibits a complex topography and significant ecological diversity; is home to twelve major river systems of Asia that provide vital ecosystems services to nearly two billion people upstream and downstream, both directly and indirectly; and thrives on a diverse network of human settlements reflecting deep-rooted cultural and architectural traditions and resource management practices, adapted to the sensitivities of mountain ecosystems.

But these settlements are now threatened by the competing pressures of escalating climate change and exacerbating climate events, unplanned development of the mountain areas under rapid urbanisation and changing land use patterns. Not only is the rate of built-up area expansion in the HKH region 1.7 times higher than the population growth rate in the region, but these rapidly rising modern infrastructure are mostly steel and reinforced cement concrete (RCC) structures that put substantial pressure on biodiversity, water and energy security of the mountain communities.

The haphazard development of the concrete-based infrastructures leads to further adverse land conversion, worsening of ground water recharge, increased emissions, and pockets of heat islands; and entails higher operational costs of both heating and cooling. With such rapid concrete-based urbanisation, the region's traditional vernacular architecture and heritage sites, embodying the identity and culture of the mountain communities, are continually eroding Therefore, it is imperative to minimise these urban settlement trade-offs and balance between environmental, socio-cultural, and economic development goals. Restoration and adaptation using locally sourced nature-based settlement solutions are key to maintaining the delicate harmony between the mountain people and nature, and achieve sustainable outcomes.

This document is a collection of 20 cases of innovative / best practices and technologies from across Bangladesh, Bhutan, India, Myanmar, Nepal, and Pakistan that integrate traditional knowledge and use of local building materials with modern design, towards reducing embodied carbon footprints and strengthening community resilience. These cases provide context-specific solutions for sustainable and resilient infrastructure, particularly for the housing sector in the HKH.

The aim of this collection of cases is to promote regional learning on best practices and innovative approaches for sustainable and resilient infrastructure, particularly focusing on building/housing design that supports the preservation of vernacular architecture, provides affordable and safe shelters, and is built on low carbon emission pathways, while addressing the development needs and aspirations of the HKH mountain communities.

Based on the evidence gathered from the best practice cases, this document can provide a roadmap for strategic investments and enabling policies for prioritising resilient housing and sustainable construction in the HKH region through:

Promotion of nature-based and low-carbon materials such as, the (demonstrated) use of bamboo, mud, earth, lime, and hempcrete to replace energy-intensive materials, while maintaining cultural relevance and affordability.

Revival and adaptation of vernacular architecture by showcasing updated applications of traditional systems such as Kath-Kuni, Lepcha, and Machang houses that blend Indigenous knowledge with modern engineering for thermal efficiency and (climate/natural) disaster resilience.

Post-disaster recovery and climate-resilient design by documenting reconstruction approaches from Bhutan and Myanmar that combine local materials with structural innovations for safer rebuilding.

Integration of digital and scientific tools such as, application of GIS and remote sensing technologies to guide safer, climate-resilient housing and settlement planning in hazard-prone regions.

Community-led and inclusive approaches highlighting participatory, gender-inclusive projects that build local capacity and ownership, while improving access to affordable and disaster-resilient housing.

The practical solutions documented in this collection are relevant for policy makers, researchers, educators, practitioners, architects, engineers, and development organisations, working towards leveraging enabling policies and investment opportunities (including blended finance) to scale these solutions and best practices across the mountain settlements in the HKH region.

Introduction

The HKH region is one of the most important mountain regions in the world with a combined population of 3.36 billion or 42% of the global population, which grew at an annual rate of 0.9% between 2011 and 2021 (World Bank,2021). The region is witnessing rapid and often unplanned urbanisation dominated by RCC structures. The high-rise, RCC buildings not only undermine the natural and cultural character of mountain settlements but also contribute significantly to carbon emissions. This choice of building material is crucial as 40% of the global emissions are attributed to the construction sector alone. While infrastructure development is vital for improving connectivity and access to services, poorly planned construction in ecologically sensitive areas is intensifying erosion, resource depletion, and vulnerability to natural hazards (Kulkarni et al., 2021; Vaidya et al., 2019).

The HKH region holds a long history of adaptive, nature-based, and community-rooted building traditions. Local materials such as stone, timber, bamboo, earth, and lime have long been used to build resilient and climate-responsive housing, suited to mountain environments. Yet, these practices are being rapidly replaced by resource-intensive, high-emission construction materials. The loss of vernacular knowledge, combined with limited access to affordable, low-carbon technologies, threatens both environmental integrity and cultural heritage across the HKH.

In this context, there is an urgent need to systematically document, and share sustainable building practices and innovative approaches that bridge traditional wisdom with modern design. This collection of best practice cases aims to promote peer learning and knowledge exchange across the HKH region. It showcases a range of context-specific best practices, highlights the integration of nature-based solutionsinto architectural designs, and identifies the critical barriers to scaling these innovations.

The range of best practices featuring in this document spans from post-disaster rebuilding, construction in flood-prone areas, and the preservation of vernacular hill and mountain architecture. Through the evidence gathered from diverse mountain contexts, this volume presents alternatives that could inform policies and planning processes for encouraging low-carbon, disaster-resilient, and inclusive infrastructure. By presenting demonstrated examples of resilient housing using sustainable building materials, passive design, and energy-efficient practices, this document contributes to advancing a green, resilient, and inclusive settlement development pathway for the mountain communities in the HKH region.

1

Hira Tariq
The Aga Khan
University Hospital

Eco-Friendly Bamboo-Mud Housing for Climate Resilience

Matiari Sindh, Pakistan

Background:

This project was piloted in the Matiari district in the Sindh Province of Pakistan. Matiari is a semi-arid district highly vulnerable to climate change induced extreme weather events, such as heatwaves, floods, and droughts. Rural communities in the district face severe shelter and sanitation challenges, making affordable and resilient housing solutions a critical need.

Case summary:

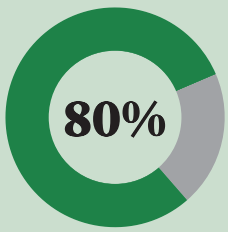
This project delivered low-carbon, climate-resilient housing using locally sourced bamboo, mud, lime, and mountain stones. More than shelter, the homes represented a scalable, culturally grounded model for climate-resilient infrastructure that protected lives, sustained heritage, and built self-reliance in climate vulnerable rural areas.

Sustainability and resilience features:

- The houses were constructed on raised stone foundations that could protect these structures against flooding; while bamboo superstructures reinforced with mud and lime plaster provided seismic safety, thermal insulation, and durability.
- The design applied vernacular architecture and passive cooling features, including breathable mud plaster, lime for waterproofing, and thatched roofing supported by bamboo trusses for ventilation.
- Passive features improved ventilation, cooling, and rainwater runoff without the use of energy-intensive inputs and /or fossil fuel.
- Each unit included an improved stove and a shared toilet to enhance health and hygiene. Water-efficient sanitation facilities, lime-sealed floors, and seepage-preventing drains conserved resources and improved hygiene.
- Drawing on Indigenous knowledge and architect Yasmeen Lari's Barefoot Architecture , local artisans and community members co-designed and built the homes using manual, low-tech methods that strengthened skills, livelihoods, and ownership, alongside ensuring affordability, scalability, and community ownership.
- With both men and women participating in construction and training, this initiative shows potential for embedding gender equality and social (community) inclusion (GESI) in decision-making.

750

bamboo-mud houses using 100% local, renewable materials (bamboo, lime, mud).



Cost reduced by 80% compared to brick-cement housing (US$180 vs. US$900–1,000).

Inclusiveness and scalability:

- Use of locally available building materials and low-tech processes, and alignment with vernacular architectural traditions, enabled community participation in the project.
- Culturally appropriate ways of harnessing women's participation have been instrumental in ensuring uptake of the project's solutions, driven by women's strong motivation for safe, durable, low-maintenance, and dignified housing solutions.
- Locally available, low-cost and nature-based technologies/solutions, community-led participatory approach, and integration of Indigenous knowledge, make this model highly scalable and adaptable / replicable to other mountainous and semi-arid regions of comparable terrain, climate vulnerability, and resource limitations as in Sindh.
- Co-created through dialogue and hands-on involvement of communities, the model reflected cultural sensitivity, strengthened ownership, and showed how communities could lead their own resilience-building efforts. All these factors also play key roles in ensuring the sustainability of the solutions championed by the project.

Challenges and key learning:

While the project successfully combined nature-based materials, low-tech methods, and inclusive planning to create a climate-resilient housing model rooted in sustainability and equity, it also faced initial challenges in fostering community acceptance, adoption and ownership of traditional materials as climate-resilient solutions despite these being low-cost.

- Many residents doubted the strength of bamboo and mud in flood and heat-prone areas, which was resolved through demonstration units and awareness sessions.
- Limited access to treated bamboo and skilled labour was addressed by training local masons and carpenters, while bamboo treatment with lime kept the approach affordable and eco-friendly.
- Gender norms restricted women's participation, but women-only meetings enabled them to provide input on design features, and ownership of houses was registered under female household heads.
- Finding water-resistant, low-cost alternatives to cement was another hurdle, which was resolved by using lime for waterproofing and durability. Being a carbon-neutral building material, lime has low carbon footprint..

100%

Female ownership strengthened community empowerment and ownership.

Outcomes and impact:

- Reduced reliance on investment-intensive and carbon-intensive building materials and increased dependency on sustainable, low-cost resources and technologies.
- Enhanced community cohesion, dignity, and safety through culturally appropriate, disaster-resilient housing.
- Cost efficient construction, creation of local jobs and skill development through eco-constructions.
- Positive impact on domestic health and hygiene through the provision of improved stoves and water-efficient, shared sanitation facilities within the housing.

2

GIS and Remote Sensing Applications for Housing Planning

Gilgit Baltistan, Swat and Chitral, Pakistan

Owais Ali
AI Geo Navigators
Pvt. Limited

Background:

The mountainous regions of Pakistan, particularly Gilgit-Baltistan, Swat, and Chitral, are highly vulnerable to landslides, flash floods, seismic activity, glacial lake outburst floods (GLOF), and other climate-related hazards. Rugged terrain, fragile geology, and increasing climate variability amplify risks to lives, infrastructure, and ecosystems. Unplanned housing expansion on steep slopes, riverbanks, or high-risk areas further exposes communities, already imperiled by land scarcity, limited awareness, and poor access to spatial data.

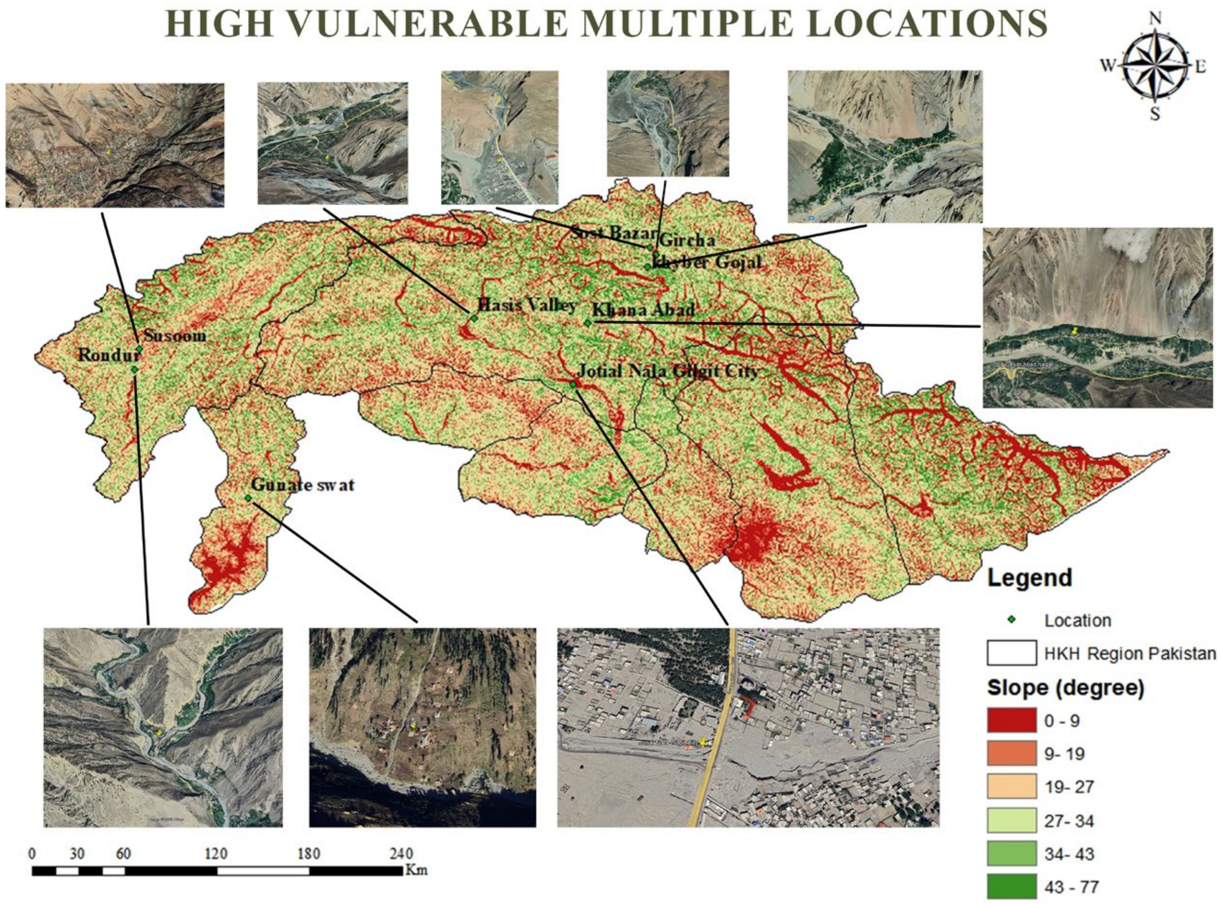
Case summary:

The project uses geo-spatial technologies to identify safe, sustainable, and disaster-resilient housing sites in Pakistan's mountainous regions. High-resolution satellite and drone imagery, combined with Geographic Information System (GIS) and Remote Sensing, can divert housing development away from hazard-prone areas. Digital elevation models, landslide susceptibility maps, floodplain and river buffer zones, seismic fault lines, historical disaster records, and rainfall patterns are overlaid with socio-economic and infrastructure data to assess safe settlement zones. Findings are validated through field surveys and local stakeholder engagement to ensure accuracy and relevance. A key feature is the integration of Indigenous knowledge, which ensures housing designs meet safety standards, remain culturally appropriate, and are affordable. This approach aligns with global frameworks such as the Sendai Framework for Disaster Risk Reduction, Sustainable Cities and Communities and Climate Action, providing a replicable model for hazard-informed, context appropriate and resilient housing planning.

Sustainability and resilience features:

The project integrates sustainability and disaster resilience into housing planning by combining geo-spatial risk analysis with climate-smart construction and community knowledge of disaster-prone areas.

- GIS and Remote Sensing identify low-risk sites away from floodplains, landslide-prone slopes, unstable terrain, and seismic fault lines, while multi-criteria overlay analysis considers slope, rivers, and proximity to essential services such as water, roads, and emergency shelters. Disaster-resilience, therefore, is embedded in the planning process, ahead of the construction of the housing structures.
- Community validation incorporates local knowledge to ensure contextual appropriateness and social acceptance.



- Houses are built with locally available, low-carbon, and biodegradable materials such as stone, mud, timber, and compressed earth blocks, providing natural insulation and reducing reliance on artificial heating or cooling.
- Energy efficiency is enhanced through passive solar design, ventilation shafts, strategically placed windows, sloped roofs, and overhangs.
- Disaster resilience is ensured through raised foundations, stone masonry with timber reinforcement, and site-specific drainage to manage flood and runoff risks.

Inclusiveness and scalability:

- A community-driven and local resource-sensitive approach maximised participation of local communities, minimised costs and promoted long-term sustainability.
- Community participation is further strengthened by involving local artisans, masons, and carpenters with inter-generational experience in vernacular construction techniques like stone masonry, mud wall finishing, and wooden frame carpentry, instead of outsourcing construction to external contractors.
- The project adopted a GESI framework to ensure that youth, women and marginalised groups were actively involved at all stages.
  - Women, for instance, were consulted for site selection, design consultations, and household planning, offering input on privacy, safety, storage, and kitchen layouts.
  - Youth were engaged in 13 technical training sessions on GIS mapping, construction safety, and climate-resilient practices.
  - Hands-on training sessions and workshops were conducted for local workers on disaster-resilient construction techniques, including how to build elevated foundations, apply seismic reinforcements, and design climate-adaptive layouts.
- A bottom-up approach of project management involving community elders, local government bodies, and technical advisors in joint decision-making processes fostered local ownership and trust, ensuring the long-term maintenance and success of the housing units.

Combining GIS, Remote Sensing, multi-hazard risk mapping, and community validation, this model can be replicated in Gilgit-Baltistan, Khyber Pakhtunkhwa, and beyond. The model holds much potential of scalability / replicability on the following grounds:

- Use of free satellite imagery, open-source tools, and local materials, ensure its cost-effectiveness.
- Its modular design supports implementation from village to provincial levels, with reusable training modules for local capacity building.
- This adaptable, data-driven model supports national housing policies, disaster risk reduction, and climate adaptation globally.

Challenges and key learning:

The project faced several challenges, including lack of accurate hazard data, cultural resistance to new construction techniques, limited financial resources, gender exclusion in planning, and low local technical capacity. These challenges were addressed through several strategies:

- Use of remote sensing, free satellite imagery, and drone technology combined with community-led mapping to identify safe sites for construction, help to overcome the data constraint.
- Locally sourced low-carbon materials such as stone, mud, and timber reduce costs while ensuring durability.
- Demonstration houses integrating traditional aesthetics with modern safety standards help in overcoming cultural barrier and encouraged active engagement of local elders.
- A GESI approach engaging women and youth in the planning process, especially for enhancing privacy, accessibility, and functionality of the houses, and hands-on training for local technical skills/ capacity development in resilient construction, ensure community ownership, including long-term maintenance of the housing structures.

Outcomes and impact:

The project in Gilgit-Baltistan, Swat, and Chitral generated social, environmental, and economic benefits:

- Socially, it improved safety by situating housing away from high-risk areas and involving women, youth, and elders in culturally appropriate design decisions. Capacity-building programs equipped residents with skills in GIS, resilient construction, and climate-smart practices.
- Environmentally, the initiative encouraged sustainable land use, reduced landslide and erosion risks, and employed low-carbon materials alongside passive solar design and rainwater harvesting.
- Economically, it lowered construction costs, created local employment, and minimised future repair expenses.

By combining geo-spatial technology with active community participation, the project delivered safe, sustainable, and adaptable housing, providing a replicable model for climate-resilient development in mountain regions.

3

Climate Resilient Settlement Development Plan (CSRDP)

Sindh, Pakistan

Minar Thapa Magar

Sindh Housing Recovery and Reconstruction Platform (SHRRP)/ Catholic Relief Services (CRS)-Pakistan

Background:

Catholic Relief Services (CRS) Pakistan/SHRRP is implementing various initiatives to support the Government of Sindh, Pakistan, in multi-sectoral disaster management, including piloting and implementation of disaster and/ or climate resilient housing and infrastructure solutions across various locations of Sindh. CRS has developed flood-resilient construction guidelines and piloted various housing typologies like timber houses in coastal areas, and brick, block and stone houses with various roof options in the in-land areas.

Case summary:

The project focuses on flood-resilient housing and the development of building standards, mason training curriculums, and manuals. As part of the CRSDP flagship initiative, CRS supported the government in planning and implementation of climate and disaster-resilient infrastructure , including schools, sewage systems, and clean cookstoves. The timber house design uses locally sourced wood, are built on elevated stilts for flood protection, with cross-bracing, wind-resistant joints, and structurally tested pine for durability. Roofing combines local thatch and timber supports, emphasising modularity, sustainability, and cultural relevance. The brick, block, and stone houses, on the other hand, follow disaster-resilient guidelines, with deep foundations, raised plinths, and roofs made from locally available materials to ensure flood resilience and proper insulation.

Sustainability and resilience features:

- Choice of building materials such as, locally sourced timber (baghan, garo, bohara), bamboo, clay, and stabilised mud plaster reduce embodied carbon, while roofs combining clay layers and radiant barriers support passive thermal comfort without being energy intensive.
- Houses are modular, allowing horizontal expansion. Structures are designed for extreme weather and disaster resilience.
- Elevated plinths mitigate damage from floods, reinforced foundations and masonry enhance durability, and structurally tested timber and wind-resistant joints ensure safety.
- The project promotes low-carbon development through material reuse, water-conserving site selection, drainage systems, tree planting, and training on energy efficiency, disaster risk reduction, and build-back-better principles.

Inclusiveness and scalability:

The Sindh housing reconstruction used a community-led, resource-efficient model emphasising transparency, inclusivity, and resilience:

- Households received PKR 300,000 in four tranches tied to construction milestones, empowering them to manage reconstruction.
- Local labour is central to the construction activity, with 1,900 masons trained in disaster-resilient techniques.
- Use of local materials like bamboo, clay, and sieved sand, reduce costs; while culturally preferred timber housing typologies are familiar to local masons.
- Indigenous knowledge informs design. GESI principles are integrated with women participating in cash management, material sorting, and construction supervision. Accessibility features support persons with disabilities.
- Community engagement, orientation sessions on disaster risk reduction, and feedback mechanisms ensured ownership and inclusivity.
- Sourcing timber, accessing skilled labour, mastering construction techniques, and managing additional costs could pose challenges to scaling up. However, the Government of Sindh is replicating the in-land solutions (brick, block and stone houses with various roof options) for the reconstruction of more than 2 million homes in Sindh.

755

climate and disaster resilient homes constructed.

1,917

local masons trained in resilient construction techniques.

Challenges and key learning:

Implementation revealed challenges including material shortages, labour gaps, and exclusion of vulnerable households. High demand for bricks, timber, and other construction materials drove up costs, while limited skilled labour affected construction quality. CRS addressed these by:

- Promoting locally available, nature-based materials like bamboo, clay, and stabilised mud plaster that reduced costs.
- A pilot training for 26 local masons helped build disaster-resilient construction skills, ensured quality, and created livelihoods.
- Inclusivity was ensured through engagement of women as supervisors and in cash management, material sorting, and hygiene promotion. Accessibility features ensured usability of the structures for persons with disabilities.

Timber-based designs remain cost-sensitive despite local preference, requiring further experimentation and exploration of subsidies to promote affordable, disaster-resilient, and environmentally friendly housing.

Outcomes and impact:

- The project successfully reconstructed 755 safe and resilient homes in 9 flood-affected villages, directly benefiting flood-affected families in Sindh.
- Environmentally, it promoted low-carbon construction using bamboo, clay, and recycled materials, reducing emissions and supporting ecosystem restoration.
- Socially, it enhanced dignity, safety, and inclusion, particularly for women and persons with disabilities, through GESI-responsive design and training.
- Economically, it generated local employment, empowered communities via cash-based reconstruction, and revitalised livelihoods.
- The initiative strengthened long-term resilience, community cohesion, and sustainable recovery.

Supported the government in planning climate and disaster-resilient infrastructure for over

1,000

villages and implemented the same in 10 model villages.

X 18

women trained as construction supervisors.

4

Sustainable Architecture for Post-Disaster Recovery in Southern Shan in Myanmar

Southern Shan, Myanmar

Naw Khine Thazin
United Nations Human Settlements Program (UN-Habitat), Myanmar

Background:

The "Sustainable Architecture for Post-Disaster Recovery" project is an UN-Habitat initiative in Southern Shan, Myanmar, launched in response to the increasing frequency of natural disasters. Typhoon Yagi in September 2024 caused widespread displacement and extensive damage to infrastructure, highlighting the urgent need for safe and dignified housing.

The project aims to provide flood-resilient transitional housing and shelters, addressing both climate risks and the vulnerabilities of communities affected by disasters and conflict. It emphasises participatory design, cultural suitability, and protection for vulnerable groups, including women and girls, while promoting long-term resilience and community empowerment.

Case summary:

The project implements low-tech, modular, and replicable shelter designs that can be quickly assembled by community members. Construction relies on locally available, renewable, and low-impact materials such as bamboo, timber, and veneer plywood, reducing the carbon footprint while ensuring affordability and resource efficiency. Standardised, modular designs with simple assembly techniques enable rapid, large-scale deployment while remaining adaptable to different community needs. The shelters are multi-purpose and flexible, serving as homes, libraries, or community centres in normal times and transforming into emergency shelters during crises. By minimising the need for specialised expertise, the approach empowers displaced households and local carpenters to build and maintain shelters independently.

Sustainability and resilience features:

This project integrates sustainability across environmental, socioeconomic and cultural dimensions:

- Environmentally, it prioritises low-carbon footprint by using locally sourced, renewable materials such as bamboo and timber, which also reduce transportation-related emissions, alongside adopting a life-cycle approach that minimises waste from sourcing to deconstruction.
- "Water-sensitive recovery" and "sponge city" principles make these shelters flood-resistant and ensure long-term durability.
- Modular, low-tech construction enables rapid deployment and reconstruction after disasters. Multi-purpose use allows shelters to serve as community or learning spaces in normal times and emergency shelters during crises.

- Affordability of the shelters along with community engagement (harnessed through participatory designing of the project, and skill building training for constructing the structures), fosters community ownership, ensures local relevance and long-term resilience.

Inclusiveness and scalability:

The project adopts a community-centred, collaborative management approach to ensure inclusiveness:

- Local procurement supports the local economy and reduces logistical challenges, while engagement of (displaced) community members, including youth, in co-designing and construction, through skill building training, foster ownership.
- Enhanced features of the shelters, such as lockable doors and separate rooms, are designed keeping in mind the privacy of women and girls, in particular.

The critical success factors for replication are the participatory design model and the use of local, nature-based materials.

- The solutions can be adapted to other mountain settlements by tailoring the design to the locally available materials and by engaging with local communities to understand their unique cultural and environmental needs.
- The low-tech, modular design ensures that the approach is highly scalable without requiring extensive technical expertise or large-scale industrial production.

Challenges and key learning:

- Lack of accurate hazard data was among the major challenges faced by the project. This was addressed by combining remote sensing, satellite imagery, and drone technology with community-led mapping to select safe sites.

The resulting shelters, made of natural and locally available materials, directly benefit nearly

2,000

students

During natural hazards, each building can accommodate over

100

people at a time

- Demonstration houses combining traditional aesthetics with modern safety standards helped in overcoming cultural resistance to new construction methods by eliciting interest and involvement of the community elders.
- Locally sourced, low-carbon materials such as stone, mud, and timber reduced costs while ensuring durability, thereby addressing the constraint of limited financial resources.
- Active involvement of women and youth in designing the shelters, especially for improved privacy, accessibility, and functionality features; and hands-on training for strengthening local technical skills, ensured inclusiveness of the project, made it culturally relevant and supported long-term community ownership and maintenance of the structures.

The project demonstrated that communities can be empowered to value local materials and techniques, adapt designs to regional climate conditions, and participate meaningfully in construction, without heavy reliance on external expertise.

Outcomes and impact:

The resulting shelters, made of natural and locally available materials, directly benefit nearly 2,000 students in Taung Gyi and Kalaw townships. If used as an emergency shelter during natural disasters, each building can accommodate over 100 people at a time. This dual-purpose design ensures that the facility remains a resilient asset for both education and disaster response. During the workshops, students expressed excitement over the design and shared innovative suggestions for making the spaces flood-resilient and comfortable.

5

Strengthening Bhutan's Construction Governance with Global RICS Standards

London, United Kingdom

Lungten Tshering
Kingston University

Background:

Bhutan is undergoing rapid infrastructure development within a unique cultural and policy environment guided by its philosophy of Gross National Happiness (GNH), and motivated by national reforms, such as the 2020 National Construction Policy and the 2023 Building Regulations. However, the sector faces persistent issues, including cost overruns, limited professional capacity, and reliance on foreign labour. Against this backdrop, this case examines the readiness of Bhutan's construction industry to adopt global standards, highlighting opportunities for phased adoption and capacity-building that can strengthen infrastructure quality and resilience in the HKH region.

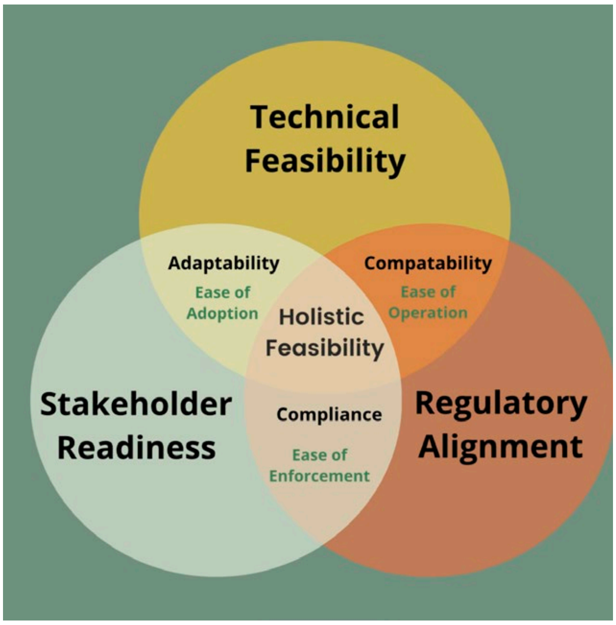
Case summary:

This case examines the feasibility of Bhutan's construction sector in adopting Royal Institution of Chartered Surveyors (RICS) standards to enhance infrastructure quality and resilience. RICS is a globally recognised professional body that sets standards for construction, land, and real estate practices, promoting integrity, quality, and sustainability in the built environment. Rather than focusing on a single building, it looks at systemic conditions shaping design, construction practices, and material choices. The case highlights how RICS standards can improve cost estimation, transparency, and accountability, enabling better decisions on design, use of local and nature-based materials, and disaster-resilient practices. By aligning with international management standards, the case also supports the adoption of low-impact techniques such as timber, stone masonry, and compressed earth blocks, consistent with Bhutan's cultural and environmental priorities. The objective of this case is to inform the process of developing more sustainable and climate-responsive public infrastructure and housing across the country.

Sustainability and resilience features:

Using RICS standards can improve cost efficiency, risk management, and project oversight:

- These standards support reducing waste, rework, and poor use of resources; local job creation in areas like surveying, valuation, and project management through capacity building training; improving transparency and access to best practices for the small and medium contractors in Bhutan.
- Environmental sustainability comes from encouraging the use of local materials and traditional low-impact methods such as timber, stone masonry, and rammed earth; and by adhering to building regulations that take environmental concerns into account.



- Cultural sustainability is protected by linking construction reforms to Bhutan's Gross National Happiness (GNH) philosophy.
- International practices can be introduced gradually, with a focus on ethics, participation, and respect for local values.

Overall, RICS standards can help Bhutan build a construction sector that is transparent, resilient, and inclusive. By combining governance reforms, local capacity building, and sustainable practices with cultural values, Bhutan can create infrastructure that is better prepared for climate change and long-term development.

Inclusiveness and scalability:

- Gender equality and social inclusion are promoted through inclusive training, mentorship, and through national service programmes like De-suung and Gyalsung. These open opportunities for a more diverse and fairer workforce.
- Bhutan's construction industry is moderately prepared to adopt international management standards. A majority of the workforce is young professionals with growing technical confidence but limited experience, and significant gaps in skills and awareness. Addressing these gaps will require structured capacity building, including mentorship, train-the-trainer programs, and continuing professional development.
- To curb down informal and unstandardised practices in Bhutan's construction sector, and to translate the country's cultural values into consistent practice, stronger governance frameworks and leadership are needed. These will ensure efficient use of resources and create equal opportunities for all professionals. Strengthening skills and professional standards in this way will help build a more capable, inclusive, and resilient construction sector.
- The mixed-methods design of construction projects, combining surveys with the Delphi consensus approach, provides a rigorous and adaptable framework for assessing readiness for international standards in similar developing economies. The approach offers a blueprint for evaluating technical capacity, governance, and procedural resilience in complex socio-cultural contexts.
- Steps like phased capacity building and systemic feasibility assessment can be replicated for other mountain settlements in the HKH region, supporting interventions that are culturally appropriate, environmentally responsible, and inclusive.

Challenges and key learning:

Bhutan's construction sector faces gaps in technical skills, limited awareness of global standards, and reliance on informal practices, reflecting deeper challenges in governance and workforce development. This case shows that a phased capacity-building approach, including train-the-trainer models and mentorship, can address these gaps, while reducing reliance on foreign consultants. Embedding GESI ensures broader participation and benefits marginalised groups. Aligning reforms with Bhutan's GNH philosophy encourages environmentally conscious decisions, ethical standards, and accountability. Pilot-based implementation and stronger governance frameworks can make these reforms practical, culturally relevant, and scalable, supporting a more resilient, inclusive, and globally aligned construction sector.

Outcomes and impact:

This case has fostered meaningful engagement with key industry bodies like RICS, sparking international interest in Bhutan's integrated approach to sustainable development. By bridging traditional Himalayan construction practices with modern, nature-aligned innovations, it challenges the false divide between rural sustainability and global progress. The case offers practical frameworks for harmonising cost, scope, and timing across Bhutan's built environment, empowering policymakers, industry associations, and academics to collaborate effectively. Ultimately, it advances a vision where ecological respect and global relevance coexist, providing a valuable model for sustainable development in mountain regions and beyond.

6

Resilient Rural Housing in Bhutan: Paro Hempcrete and Mud Prototype

Paro, Bhutan

Matej Vacek
Tarayana Foundation

Background:

Since 2003, Tarayana Foundation has supported the construction of over 2,600 houses in rural Bhutan. The Foundation is now entering a new phase focused on building not just more homes, but better ones, sustainable and resilient to climate change. Rural development begins with decent housing, yet many homes in remote villages remain rundown or makeshift and unfit for living. Traditional building techniques have changed little over the centuries, and even newer houses are often poorly designed, wasting space and resources while remaining vulnerable to natural disasters. A key prototype nearing completion is a family house in Gomche village, Paro, designed for a family of six, currently living in inadequate conditions.

Case summary:

The project aims to provide comfortable homes while preserving traditional aesthetics and using local craftsmanship. The ground floor, built with rammed earth techniques and Bhutanese decorative elements with technical improvements, such as insulated wooden cornices and upgraded (two-glazed) windows, includes a bathroom, wash counter, guest room, and living area with a kitchen. The upper floor uses an innovative lightweight staggered timber frame, replacing the heavy timber post-and-beam structure, with hempcrete infill for insulation, and diagonally woven bamboo supports. This floor accommodates three bedrooms and an altar room. Floor plans are optimised for efficient space use and functional zoning.

Sustainability and resilience features:

The double-story buildings offer several energy efficiency advantages by combining the use of environment-sensitive materials and climate-resilient designing:

- Hempcrete (even when mixed with lime) provides insulation, thermal comfort, and fire resistance -all with a negative carbon footprint.
- While the compact square footprint of the buildings - with larger south-facing windows for solar gain and smaller north-facing openings - reduce heat loss, the staggered timber frames with hempcrete infill provide earthquake resistance and the breathable, nature-based construction materials, roof overhangs, and elevated plinths protect against moisture alongside maintaining indoor comfort.
- Energy consumption is further minimised with a central hot-air heating system powered by a local wood stove, distributing heated air through a double-wall chimney.

- The use of lightweight staggered frames, replacing heavy post-and-beam structures, reduce timber use is by at least 25%.
- Indigenous knowledge guides timber joinery, decorative elements, craft skills, and spatial layouts, including altar placement and entrance orientation, all reinforced with modern engineering to create a culturally appropriate and technically resilient housing facility.

Inclusiveness and scalability:

Tarayana Foundation's community-based approach, mobilising local resources and labour, and leveraging Indigenous knowledge, is the mainstay of inclusiveness of this project:

- Locally sources materials (such as, mud for the rammed earth walls and stone foundation mortar, timber for staggered frames, hemp used in the infill for insulation) together with Indigenous knowledge like the ekra (bamboo mats and plaster) wall tradition, ensure contextual relevance and cultural suitability to garner community ownership of the project.
- The village community was involved right from the inception of the project, including in selecting the beneficiary family. Women and marginalised groups were actively included in decision-making and training to promote gender equality and social inclusion.

Construction of over

2,600

houses in rural Bhutan

Timber use is reduced by at least 25%

- Community engagement was made possible via skill development training, and through opportunities leveraged for employment/income generation – for example:
    - Hemp used in the prototype was sourced through community harvesting.
    - The prototype was built by local masons, carpenters, and villagers under the supervision of an architect and a Tarayana Field Officer.
    - Community members and craftsmen received hands-on training in hempcrete mixing and casting, staggered timber framing, energy-efficient windows, plumbing, mud and hempcrete block fabrication.
- By providing 70% of the construction materials and covering 50% of the wages/ labour costs. the foundation further strengthened community participation and ownership of the project.

This project, in general, has the potential to be replicated across the HKH region, especially where natural resources such as hemp are available.

- To ensure replicability of the model, the Foundation developed Design Guidelines for Rural Housing, based on the prototype houses that it built. These are simple and interactive guidelines for communities on the steps involved in the designing and construction process, which can be adapted for location-specific customisation of designs.
- In addition, the Foundation also conducted several workshops and lectures with students and faculty from the College of Science and Technology, Bhutan, to share knowledge and build capacity. In one such workshop held in Thimphu, in collaboration with Bauhaus Earth Foundation from Berlin, the Paro community members shared their experience of using hemp in building the prototype houses.

Challenges and key learning:

- Traditional houses are often built without proper architectural input, resulting in layouts that are less functional, have limited solar and wind orientation, and make inefficient use of materials. The project addressed this issue by integrating professional architectural guidance for site adaptation, cultural fit, energy efficiency, and cost savings.
- Material sourcing and processing also require careful planning, as hemp grows sporadically across Bhutan and harvesting is inefficient. Strong community networks and inter-village collaboration helped secure raw material for the prototypes, though timing and logistics sometimes required transporting hemp from distant sites and using simple processing tools like a woodchipper.
- Skill development proved critical for quality construction, as local craftsmen, while skilled in traditional methods, needed on-site training and workshops to master precision techniques, such as airtight windows.

Outcomes and impact:

The project demonstrated that housing built almost entirely with local materials and labour can be insulated, fire-safe, climate-resilient, comfortable, and affordable. Beyond constructing a prototype, draft design guidelines increased the potential of replication across Bhutan. Socially, the project provided local builders and craftsmen with new skills, strengthening community resilience. Environmentally, the staggered timber wall system reduced timber use by at least 25% compared to traditional methods. An ongoing doctoral research aims to fully evaluate the project, including a Life Cycle Assessment, to verify its environmental and economic benefits in more details.

7

Kath-Kuni: Adapting Western-Himalayan Vernacular Architecture for a Changing Climate

Himachal Pradesh, India

Akshita Sharma
Forest Research Institute, Dehradun

Background:

Preserving Kath-Kuni means more than saving old walls—it means restoring homes, rebuilding skills, and renewing its place in everyday life.

Kath-Kuni, which translates to "wood and corner," is a 1000-year-old Himalayan construction technique native to Kullu, Shimla, Kinnaur, and Chamba districts of the state of Himachal Pradesh in India. This technique creates walls by stacking deodar (Himalayan cedar) timber and dry stones, bound with mud. Once common in homes, this skill has largely disappeared from middle-class houses, replaced by cement and steel, as Kath-Kuni construction can cost up to three times more than concrete and requires specialised artisans, or karigars. This elegant, eco-responsive method, designed to withstand seismic activity, is now mostly limited to temples, preserved heritage structures, or isolated remote villages. Village architecture has gradually shifted from climate-resilient and aesthetically rich buildings to cemented, multi-story "matchbox" houses vulnerable to heavy rains. Preserving Kath-Kuni is therefore imperative to maintain the region's architectural heritage and resilience.

Case summary:

Kath-Kuni architecture reflects the Himalayan living tapestry of locally sourced wood and stone, built without nails, forming a sturdy woody skeleton. Between this are quarried flat sone, packed with mud and rubble for insulation. The result is thick wall, which is pest resistant, cool in summer and warm in summer, and able to flex during earthquakes. Roofs, designed for snow and rain, are framed in timbre covered with hand cut slate tiles. The ground floor is reserved for cattle, and the carved balcony adjacent to the rooms is not just decorative but also shields walls from rain and snow. Every element is well thought out keeping in mind climatic variability, shaped by skilled craftsmen, and guided by generational knowledge of architecture, making each Kath-Kuni home a unique fusion of engineering, climate wisdom, and cultural artistry.

Sustainability and resilience features:

- Kath-Kuni construction uses locally sourced timber and stone, reducing transport emissions and reliance on industrial cement and steel, and cutting embodied carbon by 30%–40% compared to RCC buildings.
- Materials are reusable, allowing timber and stone to be dismantled and reassembled, supporting circular economy principles.

- Stone plinths anchor buildings on steep slopes, elevate foundations to prevent waterlogging, and facilitate drainage. Some slopes connect to stone-lined tanks that store rainwater for dry months.
- Timber-stone walls and mud maintain soil permeability, unlike concrete structures, making Kath-Kuni resilient to destructive monsoon floods, which have historically caused significant damage and loss of life in Himachal Pradesh.
- The construction sequence, timber joinery, and wall proportions are guided by intergenerational knowledge of local climate and seismic risks. Alternating layers of deodar timber and stone act as seismic dampers, while the interlocking "kuni" lattice prevents collapse, and stone provides compressive strength.
- Thick stone walls with air gaps lower heating needs by up to 40%, important in areas with frequent winter power cuts. Building orientation follows traditional knowledge of sun paths and wind corridors, optimising solar gain and exposure.

Inclusiveness and scalability:

- As only 10% of the Kath-Kuni structures remain, preservation of these structures is very important from both aesthetic and climate-resilience perspectives, which creates demand for trained labour.
- Kath-Kuni requires specialised skills, creating opportunities for local masons to pass down the expertise to younger generations. On the other hand, it also gives the community an opportunity to invest in learning craftmanship which is niche and valued.
- Certain design elements of Kath-Kuni structures - such as thermal

Preserving Kath-Kuni means more than saving old walls—it means restoring homes, rebuilding skills, and renewing its place in everyday life


insulation and the provision of water storage – can potentially reduce the labour of local women that goes in gathering fuelwood and collecting water for household use during dry months, from distant locations.

- The management model of Kath-Kuni should involve a collaborative approach with local governments (panchayats), government forest departments, and non-government organisations (NGOs), coming together in decision-making, ensuring transparency in timber quotas, wage rates, and beneficiary selection.
- Scaling Kath-Kuni architecture depends on both safeguarding this gradually disappearing heritag and building supply chains to secure its future. This can be achieved by incentivising the restoration of old homes using this technique, creating workshops to pass down the specialised skills, and strengthening its cultural relevance beyond temples.
- With adaptation to locally available materials, this vernacular style can also be replicated across other Himalayan regions.

Challenges and key learning:

Kath-Kuni construction faces major barriers due to its high labour and material costs, strict timber sourcing regulations, and the rarity of skilled artisans. Quarrying stone is labour-intensive, timber is expensive, and wages for specialised craftsmanship are higher than that for concrete construction. Social perceptions also play a role, as cement and steel are widely regarded as symbols of modernity, discouraging wider adoption of Kath-Kuni. To address these challenges, targeted subsidies and grants could offset costs for families interested in heritage-style housing, while vocational courses in schools could equip young people with traditional building skills. Awareness campaigns highlighting Kath-Kuni's climate resilience and safety advantages over concrete, alongside heritage tourism initiatives, could shift public perception and showcase its cultural, social, and economic value.

Outcomes and impact:

Kath-Kuni architecture once served as a common building tradition but today it is largely confined to temples and isolated remote rural areas of Himachal Pradesh. Yet the heritage, aesthetic and environmental value of this architecture is immense. Environmentally, it lowers carbon emissions, saves energy, and withstands extreme weather. Socially, it preserves endangered craftsmanship and strengthens community ties. Economically, Kath-Kuni homestays can generate higher supplementary income as tourists increasingly seek an "authentic Himalayan experience." Revitalising Kath-Kuni can therefore advance sustainable mountain development, while safeguarding cultural identity.

8

Repurposing Materials for Improved Cattle Sheds

Upper Mandi District, Himachal Pradesh, India

Anshul Walia
Gram Disha Trust

Background:

Gram Disha Trust works in the Upper Mandi District of Himachal Pradesh, with smallholder farmers and rural craftspeople, including skilled earth builders. The communities, though economically challenged, are culturally rich. The region lies between 1000 meters –1600 meters above the sea level, and the Trust aims to learn from Himalayan earth builders while creating conditions for their craft to thrive. In Kanaid village, a new cowshed was designed to replace older adobe sheds that had proven vulnerable to pests. The structure was conceived to be low-maintenance and adaptable for other uses if livestock keeping was discontinued. This multifunctional approach ensured flexibility for future needs while respecting local building traditions.

Case summary:

At Gram Disha Trust and Samadhaan Studios, building materials, such as stone, mud, plant biomass, bamboo, are sourced from within 50 kilometres of the site. Contemporary design is combined with vernacular methods, and the use of carbon-intensive materials like concrete and steel is minimised. In Kanaid, the new cattle shed structure drew heavily on salvaged components - red baked bricks, iron girders from a scrap dealer, timber from the old cow shed, adobe bricks for mud plaster, and reused roofing slates, doors, windows, and ventilators. The building follows a simple rectangular plan with a single-sloped roof. It combines brick masonry with a river stone foundation and finished stone plinth and uses cement-bonded brickwork with mud plastered walls. The first-floor rests on reused I-girders and timber beams, topped with plywood sheets for flooring. This approach reduces costs, lowers environmental impact, and demonstrates the value of adaptive reuse in rural construction.

Sustainability and resilience features:

- Most materials used in the project were salvaged, reducing both costs and carbon footprint.
- Mud plaster eliminated the need for water curing, keeping water use low, and only 20% –30% waste was generated, most of which are reusable.
- The engineering of the structure responds to Mandi's harsh climate and seismic risks. Tie beams strengthen earthquake resistance, smaller openings help retain heat, and traditional storage methods for dried grass support livestock needs.
- Functionality was integrated into the design. A raised feeding tray allows hay to be dropped in from roof level, and a sloped floor makes cleaning easier. Future iterations could include tool storage, further improving efficiency for farmers.

Inclusiveness and scalability:

- The structures were built almost entirely with local resources and labour and Indigenous knowledge was central to the designing and construction process.
- The workforce was diverse, with local women and men working together across plastering, brickwork and masonry respectively.
- The use of simple, low-tech construction methods made it easier to train and coordinate the teams. The aim was to create a design that could be replicated by anyone in the region, requiring only minor adjustments in size and layout.
- Designed for adaptability, components of the structure can be dismantled and reused, and the simple construction method is replicable for cowsheds or small homes.
- Traditional slate roofing over wooden purlins was applied, and the process of roof slope and slate handling were documented for replication / future use.
- The design suits farmers with fields and cows, enabling efficient storage of tools and dried grass, and making dung removal and urine collection logical and timesaving.
- This functional, low-maintenance, and sustainable solution with its adaptability and simplicity, offers a practical model that can be replicated in similar rural contexts to improve usability and meet community needs.

Challenges and key learning:

- A major challenge was dearth of skilled local labour for traditional crafts like mud plastering and slate laying. While hiring migrant labourers provided an immediate solution to this problem, it also brought forth the need for capacity building and training of the local community in these skills.
- Material choices involved trade-offs - while adobe bricks were more sustainable, their thicker walls reduced usable space, underscoring the need to balance sustainability with practicality in compact structures.
- The project also showed that functional requirements must guide design, with flooring emerging as a critical issue since cement alone proved inadequate and required a rubber mat for comfort and usability.
- A key learning was the importance of community acceptance, as users needed to be convinced of both the cost-effectiveness and the long-term environmental benefits of nature-positive construction.

Outcomes and impact:

Using locally sourced materials made the project offer affordable and economically efficient solutions with potential of replicability. Socially, the mud-plastered interiors inspired nearby residents to adopt similar natural finishes, boosting confidence in traditional, sustainable methods. Environmentally, the project reused materials, giving them a second life instead of adding to construction debris (*malba*). This approach promoted a circular building model, demonstrating how thoughtful design can integrate economic, social, and environmental benefits in rural settings.

9

Preserving Sikkim's Vernacular Lepcha Architecture

Sikkim, India

Sunil Pradhan

Background:

Vernacular architecture in Sikkim constitutes an intrinsic aspect of the community. Construction techniques, shaped by Lepcha, Bhutia, and Nepali influences, contribute to the state's architectural uniqueness. Comparable to the iconic structures and streetscapes in the western hemisphere, vernacular construction in Sikkim represents tangible heritage and indigenous creativity. These designs enhance the structural stability of constructions. Architectural variations are culturally specific, with each community employing distinct techniques. The *ikra* housing typology, also referred to as the Assam type, has been historically predominant among Sikkimese housing. Lepcha, Bhutia and Nepali designs integrating stone, wooden and earthen masonry reflect influences from Tibetan and Eastern Nepalese traditions.

Case summary:

Vernacular construction using local, nature-based materials is integral to community homesteads in Sikkim. Among them, Lepcha vernacular architecture is notable for its seismic resilience and is unique to Sikkim and areas of Kalimpong and Darjeeling in the sub-Himalayan region. Bamboo is central to the construction of these structures. For instance, *malibas* (Bambusa nutans) provides ikra for mud plaster, while *choya baas* (Dendrocalamus hamiltonii) substitutes for nails. These structures are constructed in a rectangular frame supported by timber pillars resting on wheel-shaped flat stones, which stabilise the foundational base during seismic events. This design also prevents pillars from decaying on coming to contact with moist soil during periods of excessive rainfall. The ground floor, elevated to a maximum height of six feet, functions primarily as a storage area. The upper level incorporates interlocking wooden beams, ikra plaster, and thatch roofing. The architectural layout typically features a longer north-south axis compared to the east-west dimension.

Sustainability and resilience features:

Sikkim lies in Seismic Zone IV/V, making it highly vulnerable to earthquakes, as seen during the 6.9 magnitude event of September 2011. The October 2023 glacial lake outburst flood (GLOF) further highlights risk from glacial retreat. Heavy monsoon rainfall also triggers frequent landslides, posing threats to housing and the safety of women and children. Vernacular construction in Sikkim, based on locally sourced wood, bamboo, and other raw materials, provides affordable, low-carbon, and climate-responsive housing:

- Tiered roofs, aesthetically symbolising Buddhist philosophy, functionally prevent water accumulation, thick walls and strategic windows retain heat in winter, and cross-ventilation allows smoke to exit through ridge lines.
- Lepcha architecture is distinctive for its earthquake-resistant systems. Stone bases/ plinth and elevated floors reduce seismic load during earthquakes alongside proving protection against decaying (of the timber pillars) during excessive rainfall and predator incursion.
- Interlocking wooden joints, built without nails, strengthen the frame and withstand aftershocks. Structures are often supported by stilts on hilly terrain, offering both stability and symbolic reverence to mountain deities.
- Houses incorporate functional spaces such as living rooms with kitchens, storage, prayer halls, and attics. Integrated into homesteads, they support farming, livestock, and eco-friendly food production.
- The dispersed settlement pattern reduces the chances from landslide damage compared to clustered Himalayan villages.
- Easy repair and modification using local skills sustain livelihoods of local craftsperson, while preserving architectural heritage.

17th century structures stood firm during the 2011 earthquake, while newer multi-storied buildings collapsed, revealing the enduring strength of traditional Lepcha construction.

Inclusiveness and scalability:

- Vernacular construction in Sikkim draws on local knowledge and locally sourced raw materials such as stone, bamboo, clay, dung, and timber.
- Community participation is integral to the process, with women indirectly supporting construction activities by providing food and lodging, and men being involved in masonry, carpentry and sawing work.
- Indigenous knowledge, cultural practices, climate wisdom and consideration of durability, underscore use of different varieties of raw materials like timber and bamboo, for different structures: e.g. timber timber varieties like *lapsi* for light structures, *siru* grass for roofing, *katus* and *chaanp* for walls in higher altitudes, and teak or *saugoon,* in humid lowlands.
- Intertwined with the culture, history, and religious tapestry of Sikkim, this vernacular architectural design has not only seen a transmission of this knowledge across generations and within Sikkim, but also within the broader Himalayan context, providing a model for both sustainable housing and sustainable tourism, replicable within the HKH region.

Challenges and key learning:

Sikkim's "Kutcha House" policy, while aimed at providing pucca housing for the rural poor, has encouraged the dismantling of vernacular constructions and led to a loss of traditional heritage. By promoting homogenised designs based on public works department guidelines, the scheme benefits contractors and material suppliers rather than local communities. A key lesson learnt in this case, is the need to integrate vernacular techniques, such as rammed mud construction, into housing schemes to reduce reliance on cement and iron and to adapt more effectively to Sikkim's agricultural landscape and rising mountain temperatures. Incorporating local materials and knowledge sustains traditional craftsmanship, creates local employment opportunities in the construction economy. Linking vernacular design with eco-tourism, local cuisine, and crafts can support inclusive rural development while preserving cultural identity. More broadly, housing solutions in the HKH region must be understood within the region's land-use systems, transhumance practices, traditional institutions, knowledge systems, and community cosmology.

Outcomes and impact:

Over the last decade, vernacular housing has been outpaced by concrete housing. Vernacular constructions require documentation for durability, flexibility, eco-friendliness, safety features, and cost-effectiveness. The knowledge evolved over centuries creates a harmonious integration with the built environment. Focus on vernacular construction forms must be at the core of disaster preparedness. Evidently, structures built in the 17th century withstood several climate events like earthquakes and glacial flood, while multi-storied, concrete constructions were reduced to rubble, leading to significant casualties and cost ineffective reconstructions.

10

Himalayan Architecture and Planning

Gautam's Home (Cottage in the Himalayas of Kumaon)

Chatola, Uttarakhand, India

Background:

Gautam's Home is situated in the village of Chatola near Mukteshwar, at an altitude of 1,720 meters above the sea level. The house is surrounded by orchards of local fruits, which are characteristic of the local landscape. Vertical rebars of three meters, awaiting micro-concreting, reflect a structure that accommodates the conditions of the mountain environment. The design emphasises functionality, comfort, and integration with the agricultural setting, while also reflecting the spirit of its owner.

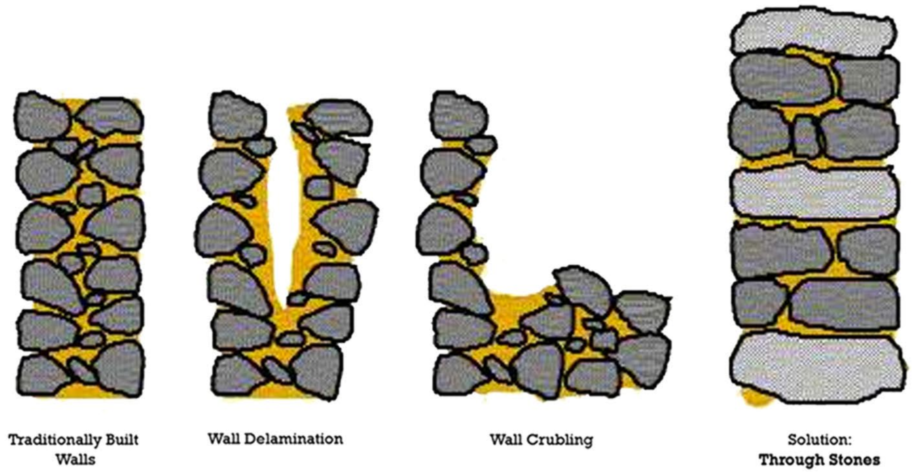
Case summary:

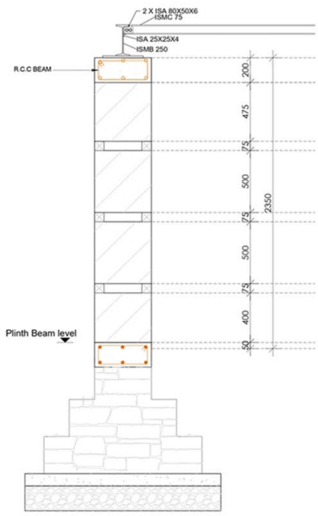
The house is a two-story cottage, built above an orchard, blending traditional elements with modern requirements. The lower level contains three guest rooms for homestay visitors, constructed with local stone masonry reinforced by timber tie bands and micro-concreting points for seismic resilience. A deck facing east-southeast provides morning sunlight and views of the surrounding hills. The ground floor, accessible from the road, includes a foyer with photo walls, a spacious living and dining area, a kitchen with a balcony, a bedroom with an attached toilet and dressing room, and a workshop space with toilet and a separate and direct road access. The upper floor is built with a mild steel frame, clad externally in Sain (Terminalia elliptica) timber and internally with an 8-millimetre (mm) fiber cement board. A centrally, insulated placed staircase on the northern side connects all three floors, ensuring efficient circulation while supporting the building's passive design strategy. The attic accommodates a meditation and yoga room opening onto two terraces that house solar water heaters and water tanks.

Sustainability and resilience features:

By integrating locally sourced materials and Indigenous building methods with modern engineering, Gautam's Home achieves a durable, low-carbon, and climate-adaptive design:

- The lower and ground floors are constructed from stone masonry reinforced with sal wood timber tie bands and micro-concreting points for seismic resilience.
- The lower floor uses locally made, breathable lime mortar, while the ground floor employs traditional mud mortar,- both minimising carbon footprint.
- Along with double-glazed windows and a north-facing staircase with glass enclosure, the roof of the upper floor using mild steel framing, bitumen shingles, rockwool insulation, and the pine panelling inside, optimise thermal comfort and natural light. While the sloped roofing efficiently sheds snow and heavy rain.
- Rainwater harvesting collects roof runoff into a 20,000-litre underground tank, and solar water heaters on attic terraces reduce energy use.





Rainwater harvesting collects roof runoff into a

20,000

litre underground tank.

Inclusiveness and scalability:

- All major building materials—including cement, reinforcement bars, mild steel, insulation, and roof shingles—were procured from within a 100 km radius, reducing transportation emissions and supporting regional suppliers.
- With 80% of the workforce for construction coming from Uttarakhand, the project fosters local employment, leverages regional skills and traditional knowledge, and supports skill development, ensuring culturally appropriate construction methods and community investment.
- By integrating local materials and labour, the project advances both environmental sustainability and social responsibility, aligning with broader goals of inclusive and resilient development.
- Passive designing, rainwater harvesting, and minimal RCC use are engineering aspects that are cost-effective, adaptable, and suited to

seismic-prone mountain regions. By respecting site conditions and engaging local labour, this model can be replicated across other Himalayan settlements, offering a sustainable, culturally rooted model for resilient mountain housing.

Challenges and key learning:

The construction of Gautam's Home demonstrated the value of responding to site conditions and evolving design needs as opportunities rather than obstacles:

- Delays caused by irregular availability of local stone were addressed through a "slow construction" approach that prioritised patience, craftsmanship, and ecological responsibility.
- Design modifications - be it integration of a natural water stream, revealed during foundation excavation, into a collection system for reuse; or repurposing of unexpected spaces, which emerged during the stone retaining wall construction, into a helper's room, or any other customised changes on the owner's requests – were met through low-impact solutions that improved adaptability, functionality, and integration with the environment.

Outcomes and impact:

Gautam's Home demonstrates a successful fusion of sustainability, cultural relevance, and economic efficiency.

- Environmentally, the use of local materials, rainwater harvesting, passive design, and minimal cement, reduced the project's carbon footprint.
- Socially, the involvement of local labour preserved traditional skills and fostered community pride. The home's personalised design and inclusion of homestay rooms support the opportunity for community-based tourism.
- Economically, sourcing materials locally and embracing "slow construction" reduced transport costs and supported the local economy. The project serves as a replicable model for resilient, low-impact mountain housing.

11

Narayan Acharya
Rammed Earth
Solutions Pvt Ltd

Rammed Earth Solutions: Sustainable Building Project

Jumla, Humla, Jhapa, Dhangadi, Kavre, Illam, Acham, Surkhet and Kathmandu districts in Nepal

Background:

The project aims to construct schools, farmhouses, libraries, residential spaces, and hospitals using rammed earth technology in Nepal. Its goal is to create healthy, sustainable, and culturally grounded infrastructure that prioritises local materials and draws inspiration from vernacular architecture and local craftsmanship. The design combines traditional earth construction with modern engineering, respecting the cultural identity and mountainous context. The project demonstrates that natural, low-carbon construction can enhance community resilience, empower local artisans, and reduce reliance on imported materials in fragile mountain environments.

Case summary:

The design integrates thick rammed earth walls, stone foundations, and lightweight metal roofs, creating a structure well-suited to high-altitude climates. Locally sourced soil and stone were processed on site, reducing transportation footprints and costs. Construction methods followed traditional practices, with hand-rammed walls built in layers of stabilised earth. Openings were carefully positioned to maximise natural light and enable cross-ventilation, providing thermal comfort without mechanical systems. The kitchen and dining areas are functionally connected yet distinct, complemented by covered verandas for year-round use. The simple form, combined with the texture of the earth walls, highlights the aesthetic qualities of local materials while ensuring durability and low maintenance.

Sustainability and resilience features:

- The project demonstrated sustainable, low-carbon design by using primarily local, nature-based materials such as soil, stone, and untreated timber, while construction wastes were reused in landscaping and plinth filling.
- The buildings are designed to withstand seismic activity, freeze–thaw cycles, and heavy rainfall:
  - Bamboo and / or rebar reinforced rammed earth wallsenhance seismic resilience and structural integrity, while the thick rammed walls are effective for passive heating and cooling.
  - Stone foundations prevent moisture and frost damage, wide eaves and roof drainage protect walls from monsoon rains, and a lightweight metal roof reduces seismic load and sheds snow efficiently.

- Passive solar design and carefully placed openings optimise natural light, ventilation, and thermal comfort throughout the year.
- Rainwater harvesting and greywater reuse improve water resilience in semi-arid mountain conditions.

- Repairable materials allow incremental upgrades and quick restoration after disasters.
- Construction sequencing (avoiding monsoon periods) helped in minimising delays, reducing erosion, enhancing safety, and avoiding damage to materials and structures.

Inclusiveness and scalability:

The project integrated equitable management with environmentally responsible construction to create a low-cost, culturally rooted, and socially inclusive model:

- Indigenous knowledge guided material selection and construction methods, integrating traditional craftsmanship with modern engineering.
- Sourcing local soil and stone reduced costs and supported nearby quarry owners and transport workers.
- The project team followed GESI principles by promoting women's participation in site organisation, cooking, and logistics. Equal pay policies, safety training, and on-site childcare support helped overcome barriers to women's involvement.
- Construction schedules were adapted around agricultural seasons to reduce conflict with local livelihoods.

Trained over

30 local builders

in rammed earth construction, expanding livelihood opportunities

Sourced about **90% of materials** locally, cutting down costs and transport emissions

- The project mobilised local labour, combining skilled masons and new trainees, working under expert supervision. About 30 community members gained practical training. Training local builders ensures long-term maintenance and replicability.
- Community participation and local leadership ensured accountability and transparency of operations /processes, while demonstration site was pivotal in eliciting community interest and acceptance.
- Volunteers and local institutions provided technical advice, reducing consultancy expenses.

The project's success depended on using local materials, securing community buy-in, and applying adaptive design that responds to climate and culture. Training local workers and employing low-tech, repairable techniques make the approach replicable in other mountain settlements. This model can be scaled sustainably across the Himalayas, where similar resources and cultural contexts are present.

Challenges and key learning:

- Limited road access delayed material delivery, which was addressed by sourcing 90% of materials locally and transporting them manually or with small vehicles.
- Construction schedules were adapted to seasonal conditions, with wall work rescheduled during dry periods to avoid monsoon.
- Scepticism about the durability of earth walls was addressed through live demonstrations, case studies, and on-site testing, while affordability concerns were managed by using local soil and volunteer labour for non-technical tasks.
- Cultural barriers to women's participation were overcome by engaging female leaders and providing safe, respectful workspaces.

These solutions were nature-positive, affordable, and GESI-responsive. Overall, flexibility, local adaptation, and community ownership were key to overcoming challenges and ensuring a sustainable, socially inclusive, and resilient project.

Outcomes and impact:

The project delivered a healthy, low-carbon kitchen and dining space, it promoted sustainable building practices and preserved Indigenous knowledge of rammed earth technique. It became a live demonstration, inspiring other mountain communities to build sustainably. Environmentally, it avoided cement and brick emissions; socially, it empowered women and youth; and economically, it reduced costs by using local materials and skills. The project has also facilitated training and created awareness about rammed earth as a practical, climate-resilient solution for Nepal's rural settlements.

12

Sustainable Building Approach in Dho-Tarap: A Story from , Remote High-Altitude Nepal

Dho-Tarap, Dolpa, Nepal

Nistha Nakarmi

Akarang Design and Build Pvt Ltd

Background:

Dho-Tarap, one of the highest human settlements in Nepal, lies in the remote Karnali region and is the site for designing a local school infrastructure. Reaching the place entails an arduous journey beginning with a flight to Juphal, then a jeep ride to Dunai, the district headquarter of Dolpa, followed by a three-day trek along shifting trails frequent landslides. The trail opens onto the trans-Himalayan landscape and leads to Dho-Tarap at an altitude of 4,080 meters above the sea level. Here the winter temperature drops to -20 degree Celsius.

Case summary:

The project involved designing an extension of the infrastructure of the Crystal Mountain School in Dho-Tarap. The design consisted of three components - a classroom block, a hostel and a multipurpose hall – all integrating traditional vernacular architecture with climate-resilient materials and design.

The classrooms were enveloped by rammed earth, with south facing sunspace to trap the natural heat. The design for the hostel was co-conceptualised with the students, their ideas shaping the Trombe walls (walls with passive solar technology), in particular. The multipurpose hall, inspired by local architecture of Gompas, was designed by a team comprising of the first civil engineer from the local village. Throughout, the design emphasised nature-based solutions, use of local materials and inclusion of the local people / community, ensuring sustainability, technology transfer and cultural continuity in this remote trans-Himalayan context.

Sustainability and resilience features:

- To withstand extreme winter temperature, the design emphasised thermal resilience. The living spaces were oriented towards south to capture natural heat and light through glazed windows and sunspaces, while the Trombe walls with high-mass insulation ensured thermal comfort and minimising heat loss.
- Further, the hostel incorporated a bubak (central fireplace) for warmth and study use, while the hall drew inspiration from Gompas.
- Roof parapets were lined with langma (local dried bush), a proven Indigenous method to prevent water seepage during snowmelt.
- Raised plinths, steeper roof slopes, and disaster-risk analysis guided site selection and construction design against flooding from shifting rainfall patterns and hailstorms.
- By adapting vernacular architecture for thermal comfort and disaster resilience, the project created not just physical infrastructure but also a community learning model for navigating climatic and geographic challenges.

Inclusiveness and scalability:

In Dho-Tarap, sustainability is embedded in daily life and building practices. The project honoured this by prioritising social inclusion and cultural continuity together with environmental responsibility. Participatory designing (of the hostel involving the students) and local capacity building (of a village engineer in the designing team of the project) ensured long-term acceptance, ownership and cultural suitability of the infrastructure.

The project is an example of perseverance for larger good. It showed that when design begins with research, is informed by vernacular wisdom and is co-built with the (user) community, the results take deeper root. The process empowered the locals, facilitated knowledge transfer through mentorship and participation, and led to community ownership of the outcome, besides reviving the esteem of local/ vernacular architecture.

With the actionable steps in place – like, deep research of place and people, understanding of Indigenous building technology, fostering community ownership and empowerment through collaborative knowledge/ wisdom sharing –this model is potentially replicable in comparable geographies.

Challenges and key learning:

- One of the major challenges of the project has been the limited availability of funds with the local community. This issue was addressed in several ways:
    - By dividing the masterplan across phases
    - By prioritising local resources, efficient resource use and community-led construction
    - By seeking funding and climate-resilient designing inputs from non-governmental organisations
- Construction was constrained by limited access and short working seasons, but the research-driven, material-conscious approach prioritised quality and cultural relevance over speed.
- In remote areas like Dho-Tarap, where accessibility is a major challenge, ensuring building standards can also be equally challenging. The project team addressed this issue primarily in two ways: first, by visiting the site physically to get first-hand information on the ground realities, and second, by fostering community participation and ownership, so that the demand for better quality standards comes from within the community and is embedded in the project design.
- Community involvement also extended to documenting the process. Their models being exhibited nationally, fostered community pride and motivation to influence local building by-laws to incorporate traditional aesthetics.

Outcomes and impact:

The project became much larger than just a building design project. It became the voice of less explored and marginalised communities demanding climate responsive design and making the government rethink their approach of 'copy paste' design. Environmentally, the project reduced carbon footprint by using local and low impact material. Socially, it rekindled community pride in vernacular knowledge provided a platform for communities to voice their demand, and eventually, influenced for new building by-laws rooted in traditions. Economically, it helped in upskilling the local engineer and in minimising material cost.

13

Climate-resilient, affordable housing and inclusive development in the HKH Region

Nepal

Shweta Sijapati
Build up Nepal
Engineering Pvt. Ltd.

Background

Build up Nepal (BUN) was founded in 2015 in response to the housing crisis that followed Nepal's devastating earthquake in the same year. BUN's community-led model and eco-friendly technology address the urgent need for affordable, disaster-resilient, and sustainable housing. Today, 2.7 million Nepali people are still in need of adequate shelter and are vulnerable to climate-induced and natural disasters. BUN trains local entrepreneurs to produce Compressed Stabilized Earth Bricks (CSEB), which is cheaper, greener and safer than pervasive, costly and polluting fired bricks. The company focuses on the inclusion of disadvantaged groups, women and youth, who represent over half of their entrepreneurs and employees in CSEB production and construction.

Case summary

CSEB is a low-cost, low-carbon alternative to traditional fired bricks. BUN has optimised the brick mix, which is produced on site using locally available materials (sand, soil, industrial waste like stone dust, with 7% cement). CSEB are compressed in a hydraulic machine - not fired - cutting carbon dioxide (CO2) emissions by 75% and air pollution by 90%. The CSEB interlock like Lego[1] , making them quick and easy to build with. Due to their larger size (and lower cement content), fewer bricks and mortar are needed in construction, which cuts down the cost of walls by 40% and that of a small two-room house by 25%. BUN utilises interlocking brick masonry and reinforces the walls with rebar, which is connected with horizontal seismic bands, making the whole structure interconnected and disaster resistant.

Sustainability and resilience features:

- CSEB technology is produced using locally available materials, industrial waste, and with minimal use of cement (7%). This eliminates the need for transportation (of materials and bricks), enables cost cutting, facilitates production in remote locations, and reduces carbon emissions.
- BUN is currently exploring the potential use of alternative stabilisers, like rice husk ash, in the brick mix to further reduce cement content, production cost and carbon emissions - aiming to develop carbon-neutral bricks by 2030.
- BUN promotes sustainable, climate-resilient housing through natural

[1]A construction toy consisting of interlocking (plastic) building blocks.

- ventilation, passive design, and rainwater harvesting, reducing reliance on artificial heating, cooling, and external water sources.
- Construction minimises waste by reusing local materials and fostering micro-enterprises that link environmental and economic sustainability.
- Homes are designed for long-term resilience using locally produced CSEB, steel rebar, and seismic bands.
- Raised foundations protect against flooding, while disaster-resistant methods address earthquakes, landslides, and intensifying monsoons.

Inclusiveness and scalability:

BUN addresses the urgent need for affordable, disaster-resilient housing in Nepal's most vulnerable regions. Their community-led approach emphasises local ownership and empowerment, and tackles climate change and inequality while fostering resilience, long-term growth, and stronger rural communities:

- Indigenous knowledge is integrated with modern standards, ensuring homes remain culturally rooted, socially accepted, and climate appropriate. The leadership team comes from rural and earthquake-affected areas, bringing firsthand understanding of community challenges.
- GESI is central to BuN's model, with over half of entrepreneurs from disadvantaged groups, 28% women, and 2% individuals with disabilities engaged in training, leadership, and construction roles.
- To date, over 200 entrepreneurs have created more than 1,600 jobs, 86% of which are held by people from disadvantaged groups, providing sustainable income and skills in rural areas.
- BUN maintains a feedback loop with entrepreneurs and verifies impact through annual third-party evaluations with Nepal's Center for Research and Development (CERAD).

11,000+

disaster-resilient, climate-friendly homes and 125 schools built across Nepal

111,000

tonnes of CO_2 emissions avoided by replacing fired bricks with eco-friendly CSEB

95% of homes are financed by low-income families themselves, showing affordability and ownership, in practice.

The critical success factors for the project are the use of locally available materials and off-grid machinery, and an inclusive approach to its micro-enterprise model. The key elements for replicating and scaling this model to other mountain settlements are:

- Empowerment of local entrepreneurs through training and long-term support
- Trust building through awareness campaigns, stakeholder engagement and demonstration trials
- Adaptability to different environments while maintaining lower cost, strong resilience, and community empowerment.
- Integrating and leveraging local knowledge and skills in design and construction.

Challenges and key learning:

- Introducing new building technology requires more than technical solutions. Many communities were hesitant to adopt CSEB over traditional fired bricks, doubting both its durability and affordability. BUN addressed these challenges in two main ways:
    - Trust building through awareness campaigns, stakeholder engagement, and demonstration buildings, which proved the value of the technology, in practice, to the communities.
    - Leveraging social media as a powerful tool for outreach, and interest generation among entrepreneurs through accessible videos.
- There is a gap in the national safety standards of constructions in Nepal, with nearly half of buildings in the country failing to meet safety requirements. To bridge this gap, the company invested in training and refresher sessions, close on-site monitoring, installing local compression testers and in creating digital learning resources.

Outcomes and impact:

With all CSEB structures withstanding the 2023 earthquake in west Nepal with low/no casualty loss, the Government of Nepal in 2024 recommended this technology in its national reconstruction guidelines. BUN has built over 11,000 disaster-resilient, climate-friendly homes and 125 schools - providing safety and dignity to thousands of people. By replacing fired bricks with eco-friendly CSEB, the company supported in removing around 111,000 tonnes of $CO2$ emission and in cutting down air pollution. Given the affordability of the technology, 95% of houses built are financed by low-income families themselves. This is igniting a shift towards climate-resilient construction and inclusive development that benefits both the people and the planet.

14

Sustainable Mountain Architecture

Madi Eco Village

Madi Village, Chitwan, Nepal

Background:

The Madi Eco-Village is a community-led initiative in Bankatta village, Madi Valley, Chitwan District of Nepal. Surrounded on three sides by the Chitwan National Park and bordering India on the south, the valley is home to the Bot people, a small community whose cultural heritage is at risk due to outward migration. The project was launched to tackle socio-economic challenges, particularly the outmigration of youth to external job markets and the resulting decline of Bot traditions. Developed in collaboration with Connecting Spaces, Sustainable Mountain Architecture (SMA), and the Bankatta Women Committee, the initiative sought to strengthen the local economy through eco-tourism while showing how modest and culturally sensitive architecture can support community resilience and cultural continuity.

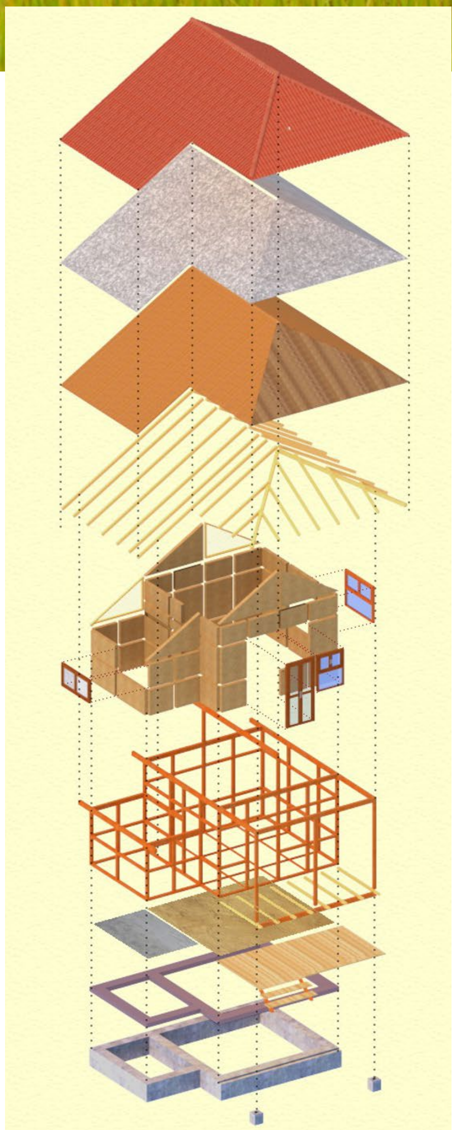
The project was a pilot initiative launched in late 2017 with the goal of creating a self-sustainable, clean, community-based eco-tourism model. The Madi Eco-Village project was formally handed over to the Bot Women Committee in 2024.

Case summary:

The project features a community hall, and two eco-cottages built with locally sourced, reused materials like treated bamboo, Sal timber, and second-hand clay tiles. The architecture is designed keeping in mind the aspects of cultural sensitivity and climate responsiveness. Beyond the physical structures, the project is a holistic model for sustainable development. A key focus is social empowerment, with training provided to local women in hospitality and accounting, and to youth in bamboo treatment. The Madi Eco-Village serves as a living prototype for culturally grounded, community-led tourism, aiming to reverse migration trends and preserve the unique Bot heritage.

Sustainability and resilience features:

- Buildings are designed for the buffer zone of Chitwan National Park using treated bamboo, reused Sal timber, and recycled tiles.
- Raised stone plinths protect against floods, while high ceilings and cross-ventilation ensure passive cooling.
- Off-grid solar panels, bio sand filters, composting toilets, and decentralised waste management provide reliable, low-impact systems for energy, water, and sanitation management.
- Resilience is embedded throughout the project design. Architecture and materials can withstand seasonal flooding and natural hazards.
- The project optimised the use of local resources by using vernacular materials such as treated bamboo, reused Sal timber, and second-hand clay tiles, reducing costs and environmental impact while celebrating local craftsmanship.



Inclusiveness and scalability:

- GESI is central to project management structure, with the Bankatta Women Committee being the primary partner in guiding decisions and operations.
- Women received training in hospitality, accounting, digital literacy, and waste management, positioning them as leaders and key beneficiaries, while addressing social imbalances and building a more inclusive, resilient community.
- A youth-led bamboo treatment enterprise adds further livelihoods and skills, strengthening the local economy.
- Diversified livelihoods reduce dependence on agriculture and migration for employment.
- Cultural identity is preserved through vernacular design, a Bot architecture library, and a community hall for gatherings and performances. By turning heritage into a sustainable economic asset, the project strengthens community pride, resilience, and long-term self-sufficiency.
- Financial resources were managed through a co-funding model with the REPIC Swiss initiative. The local community provides in-kind support through labor and materials supply, creating shared ownership of the project's success.
- By generating new income opportunities and reviving pride in Bot heritage, the project has created a powerful incentive for the local community for long-term commitment and self-management.

- The replicability of the Madi Eco-Village model hinges on several critical factors:
    - The first is a strong, community-led management structure, specifically empowering local groups like the Bot Women Committee. This ensures a sense of ownership and sustained commitment.
    - The second is an adaptive, not prescriptive, approach. The solutions must be contextualised to local conditions, leveraging available resources and traditional knowledge rather than importing expensive external technologies.
    - To replicate the model in other mountain settlements, the core principles of community ownership and culturally sensitive design must be maintained.

Challenges and key learning:

- While the initial pilot was planned for four villages, operational challenges such as misunderstandings regarding ownership and project management and disruptions due to the COVID-19 pandemic, led the partners to focus their resources on the most active community in Bankatta village. This strategic decision ensured the implementation of a successful pilot that could be replicated later.
- Co-funding from the REPIC Swiss initiative, a platform that supports projects in developing countries by promoting renewable energy and resource efficiency, proved instrumental for the project's funding, which is a key part of its management and sustainability,
- Collaboration with *myclimate foundation* for conducting a Life Cycle Assessment (LCA) of the project's environmental impact highlighted the importance of proper disposal and recycling of solar panels, batteries and other wastes, in order to avoid open burning of these. This led to more key partnerships with the Green Bamboo Creation for bamboo training, Doko Recyclers for waste management, and NEFACO for energy solutions.
- All these steps culminated into the final handover of the project to the Bot community in 2024 marking its transition from a partner-led pilot initiative to a fully self-managed, community-run enterprise.

Outcomes and impact:

The project has reduced out-migration by creating meaningful local jobs, especially for women and youth. Under the leadership of Sarita Bot, the Bankatta Women Committee has emerged central to decision-making, training, and day-to-day project management.

The initiative also strengthened Bot identity, language, and traditions through community-based tourism and cultural events held in the new community hall. More than 40 women were trained in hospitality, digital literacy, accounting, and waste management, helping them build confidence and long-term self-reliance.

The two eco-cottages and the community hall now host visitors seeking authentic cultural and ecological experiences, generating direct income for local households. While via its partnership with local enterprises - the Green Bamboo Creation and the Doko Recyclers - the project can also provide additional employment opportunities for the community youth in bamboo-based construction and landfill waste management sectors, respectively.

15

Community-Led, Nature-Based Health Clinic

Chumling, Tsum, Gorkha, Nepal

Sonam Lama

Sonam Lama Architects

Background:

The project is located in Chumling, a remote village in Lower Tsum, northern Gorkha, Nepal, situated at 2,800 meters above the sea level, on the southern slopes of Chamar (Tashi Palsang) and the Ganesh Himal valley (Kang Lombo). It goal of this project was to rebuild the local health clinic damaged by the 2015 Gorkha earthquake and restore year-round healthcare for an isolated community. The project responded to chronic health worker absenteeism due to poor infrastructure by providing a warm, resilient, and functional clinic. Community participation—particularly of women—ensured local decision-making, generated income, and preserved vernacular knowledge adapted to seismic resilience. As a result, the clinic is not only safe and culturally appropriate but also rooted in community ownership.

Case summary:

The single-storey, L-shaped structure combines a wooden interior box with dry-stone masonry walls and includes birthing rooms, patient care spaces, a kitchen, and sanitation facilities. Guided by the Nyingmapa Buddhist context, construction followed local rituals and integrated traditional motifs. The clinic is designed with passive solar principles. Its south-facing facade maximises sunlight exposure, and the relatively narrow width retains heat during freezing nights. The L-shaped plan is separated at the foundation to prevent structural friction between adjoining blocks during earthquakes, while a walking passage links the two blocks under a unified roof. A key feature is the vernacular seismic-resilient building technique known as *nang che* - a wooden interior box with dry-stone masonry exterior walls - and the use of local, nature-based materials—stone, timber, and fast-growing Himalayan bamboo—combine ecological sustainability with earthquake safety and traditional architectural aesthetics, preventing collapse and protecting occupants during seismic events. Wooden ring beams at sill, lintel, and roof levels stabilise the structure, while lightweight timber gable walls (putali gaaro) and a corrugated metal roof secured with gabion wires enhance resilience against wind and snow.

Sustainability and resilience features:

- Use of locally sourced, nature-based raw materials like stone, wood, and bamboo, made the structures cost-efficient, environment-friendly and disaster resilient.
- Earthquake resilience was achieved by combining a wooden inner box with an outer dry-stone masonry wall, preventing collapse and protecting occupants if masonry failed, while wooden ring beams at sill, lintel, and roof levels, built to national codes, further strengthened the seismic performance of the structures.

- Lightweight wooden gable walls (putali gaaro) reduced risk during quakes, while the corrugated galvanized iron roof was anchored with gabion wires to withstand snowstorms and windstorms.
- Design features included improved cooking stoves to reduce firewood use and indoor air pollution, a septic tank and soak pit to manage sanitation, waste management system to manage medical waste safely, and solar panels and a solar water heater to ensure continuous power and hot water supply.
- Water was drawn from a nearby spring, managed collectively by the local community.
- Renewable energy solutions minimised fossil fuel use, while on-site sanitation and medical waste management prevented soil and water contamination.

Inclusiveness and scalability:

Community participation strengthened social cohesion while ensuring the clinic met local needs:

- Locally sources, renewable raw materials, including stone, sustainably sourced timber, and fast-growing Himalayan bamboo (Thamnocalamus spathiflorus), helped in reducing transport emissions, preserving traditional landscapes and promoting local economies.
- Engagement of village masons, carpenters, and unskilled workers kept costs low and strengthened the local economy.
- Local community involvement in key decisions regarding the clinic's location, room layout, and in managing facilities like a kitchen garden, septic tank, soak pit, and waste management system, ensured long-term ownership and maintenance of the project by the community itself.
- Women were central in planning, deciding birthing room placement, kitchen garden layout, medicinal waste management, and overall site organization.
- Cultural integration was central to the project design, with rituals such as *salang*, *ramney*, and *jinsa* observed during construction, and windows and doors carved in the local style. This ensured the cultural appropriateness of the project.

This participatory approach fostered ownership across genders, strengthened social cohesion, and ensured the clinic addressed the needs of all community members, including the most marginalised.

Critical success factors include use of vernacular, earthquake-resilient construction, locally sourced materials, community participation, and integration of cultural practices. These solutions can be adapted to other mountain settlements. Passive design principles, sustainable energy solutions, and culturally appropriate features can be tailored to local climate, topography, and traditions.

By combining affordability, ecological sustainability, and resilience, this approach provides a scalable model for safe, inclusive, and culturally sensitive healthcare and community infrastructure across remote Himalayan regions.

Challenges and key learning:

- To address unreliable micro-hydroelectricity, the project relied on solar energy use, thereby making it energy efficient, cost effective and environment friendly.
- On-site training of local masons and carpenters helped in preserving Indigenous knowledge and integrating it with the seismic-resilient building technique, nang che, thereby reducing reliance on external contractors, lowering the costs of construction in a remote location, and fostering active community participation.
- GESI-responsiveness was supported through the capacity building of women in understanding safety benefits for their families and the community.

The project highlighted the value of building local capacity, integrating cultural practices, and addressing infrastructure gaps by providing solutions that are nature-positive, affordable, and GESI-responsive.

Outcomes and impact:

The rebuilt Chumling Health Clinic delivers year-round healthcare in a safe, warm, and culturally appropriate environment. Environmental benefits include reduced carbon footprint through local materials, renewable solar energy, sustainable bamboo use, and improved stoves lowering firewood consumption. Social impacts include women's empowerment in decision-making, preservation of cultural identity, strengthened community cohesion, and improved maternal and child healthcare. Economic advantages include local job creation, skill enhancement, reduced construction and maintenance costs, and minimized reliance on imported materials. The clinic now operates reliably despite power outages, serving as a model for resilient, affordable, and inclusive infrastructure in remote mountain regions.

16

Tyler Survant
Building Bureau

Ekuwa Health Post

Sankhuwasabha, Nepal

Background:

The Ekuwa Health Post is a sustainable, community-centered facility in Nepal's remote Sankhuwasabha District, situated at an elevation 2,200 meters above sea level, near Mt. Makalu. With no vehicular access, villagers currently walk hours for basic healthcare.

According to the Nepal Living Standards Survey, 41% of rural households don't have access to a health post to aid basic life-saving emergency services. This population faces significant health risks, especially during monsoon season, when travel becomes dangerous and health emergencies often go untreated. Expectant mothers frequently endure pregnancies without medical support, and minor injuries or infections can quickly escalate into life-threatening situations.

While state road development is slowly progressing toward Ekuwa, the health post will provide essential and timely care to communities that have long been underserved, thereby helping them to prevent avoidable complications and improve their overall health outcomes.

Case summary:

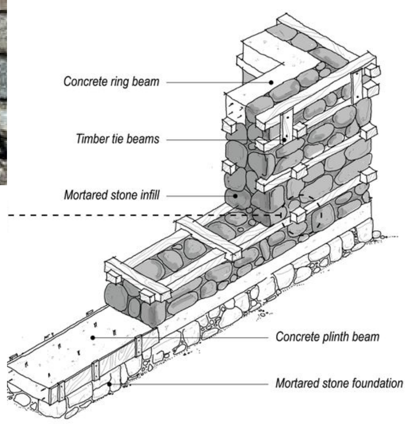
The Ekuwa Health Post is designed as a community and climate conscious operation, constructed in collaboration with local stakeholders to serve healthcare to the last mile. The health post will serve Ekuwa's 30 households and four neighbouring villages, reaching about 495 people—mainly the Sherpa and Bhote families.

The building has been constructed by 10 self-taught villagers, using primarily timber and stone sourced from the vicinity of the building site. This approach not only reduces the carbon footprint by minimising transportation emissions but also honours traditional building practices and local expertise.

By incorporating technical engineering and architectural practices with indigenous building techniques while teaching villagers about best practices along the way, the project fosters long-term resilience and self-sufficiency. The Ekuwa Health Post stands as a vital resource, blending essential healthcare and environmental stewardship with local empowerment.

Sustainability and resilience features:

The Ekuwa Health Post exemplifies a holistic and realistic approach to sustainability, integrating environmental stewardship, socioeconomic empowerment, and cultural respect. The project expands essential healthcare services to a remote region, directly addressing a critical gap in local infrastructure.



- The facility's construction prioritised locally available timber and stone and resource-efficient design.
- Timber frames and thick stone walls provide natural insulation, which is critical to regulate the temperature for the site's cold nights and winters and long days of direct sunlight.
- The post is purposefully designed for resilience against environmental and climate stresses, particularly seismic activity and heavy rainfall common in Nepal's mountainous regions:
    - The thick stone walls provide structural stability; while the strategic placement and design of timber joints – drawing on both engineering tactics and indigenous construction knowledge – enhances the building's flexibility during inevitable seismic activity.
- The buildings' high elevation and eastern orientation over the Arun River valley maximise natural light, reducing the need for artificial lighting during daily operations.
- Water conservation is a central feature of the project. A dedicated and accessible water tank ensures reliable supply for both the health post and for the daily use of the local community, alleviating the burden (especially of women) of walking long distances daily to collect water. The project also promoted community-wide resource sharing.

Health post will serve Ekuwa's 30 households and four neighbouring villages, reaching about 495 people

Inclusiveness and scalability:

The Ekuwa Health Post was initiated by a partnership with Makalu-based NGO NPO Nepal. The project harnessed community expertise and cultural awareness, ensuring the facility reflects local customs and needs. The health post was designed and built in partnership with local residents, fostering a sense of ownership and pride.

- Construction provided employment to 10 individuals engaged throughout the building process, creating valuable income opportunities for residents who often lack access to stable, locally based work.
- Upon completion, certified nurses—who have families in the area—will operate the facility, further anchoring economic benefits within the community and GESI responsiveness.
- Nurses, native to the Makalu region, representing Sherpa, Bhote, Rai, and Gurung ethnic groups, ensure care is sensitive to local customs, traditions, and health-related concerns, making the health post a truly inclusive and responsive resource.
- The project is built on land donated by a villager for the sole purpose of constructing a health post for the local communities, facing a dearth of healthcare services for over a long time.
- By improving access to healthcare and jobs, the health post empowers families to remain and thrive in their home villages, reducing migration to urban centers and preserving the unique culture and continuity of mountain communities for future

The Ekuwa Health Post's replicability and scalability stem from deep community engagement and a strong focus on education and training throughout planning, construction, and operation. By adapting solutions to local resources, cultural norms, and environmental conditions, and involving residents in every step—including land donation—the project fosters a community-first model.

Flexible material choices and active participation empower communities to envision and drive growth collectively. This approach builds local capacity and ensures long-term sustainability, making the health post a scalable model for other remote mountain communities seeking resilient, culturally sensitive, and sustainable healthcare infrastructure.

Challenges and key learning:

- With a limited budget, the project required a phased approach of operation, the first phase being the delivery of essential services while allowing careful resource allocation and ongoing community engagement.

- The project highlighted that material selection must balance local availability, environmental impact, and practicality, and that switching from rammed earth to locally sourced stone minimised transport emissions, reduced costs, and supported nature-positive construction.

- Finally, relying on a self-taught local construction team revealed the importance of adaptive training and remote supervision. Despite limited prior experience with timber joints and cement foundations, the villagers successfully integrated new techniques, creating a collaborative learning environment that strengthened both local capacity and architectural oversight.

Outcomes and impact:

The Ekuwa Health Post will serve 495 people across five villages, providing timely treatment and reducing preventable health complications. By lowering the cost of heathcare and offering critical maternal support, the clinic addresses major barriers to health and wellbeing. Environmentally, its locally sourced stone construction supports disaster resilience. Socially, it empowers communities through inclusive staffing and improved access to specialists, such as visiting dentists. Economically, it reduces travel and treatment expenses, while building local capacity for sustainable healthcare delivery. The health post will significantly improve maternal health in Ekuwa and surrounding villages, as it will offer critical assistance for expecting mothers. Additionally, the nurses who will be staffed to operate the facility are from the surrounding villages and have both professional and personal care and consideration for the success of the facility.

17

Lime Stabilised Soil (LSS) Technology for Flood Resilient Construction in Banke and Jumla

Reshma Shrestha and Rupesh Shrestha

Sinja Valley (Jumla) and Rapti-Sonari and Duduwa (Banke), Nepal

Background:

Nepal's varied geography creates distinct housing challenges across regions, calling for locally adapted, climate-resilient solutions. In the mountain settlements of Sinja Rural Municipality, Jumla, traditional flat-mud roof houses built with stone, timber, and mud reflect deep cultural heritage, but are facing growing risks from intense rainfall, freeze–thaw cycles, and earthquakes.

As modern cement construction remains costly and thermally inefficient for the cold, high-altitude climate, the Uthan Project, funded by Caritas Germany and Caritas Nepal, and implemented by PACE Nepal, introduced Lime-Stabilized Soil (LSS) technology as a heritage-compatible and low-carbon alternative at mason training in 2025. Integrating LSS into wall plastering, roofing, and flooring improve earthquake resistance, thermal comfort, and weather durability while preserving the vernacular form.

The low-lying Terai plains in the country, on the other hand, face recurring monsoon-induced floods that cause extensive damage to the traditional wattle and daub houses built with bamboo or timber frames and mud plaster. Banke district alone has experienced several severe floods since 2014, leaving many rural families trapped in cycles of repair and rebuilding. Without construction standards suited to low-cost, vernacular housing, these communities remain highly exposed to erosion and collapse.

To address this, CRS Nepal piloted the use of LSS technology in timber and bamboo-framed demonstration houses in Rapti-Sonari and Duduwa municipalities. The application of LSS improved wall strength, reduced water erosion, and provided a cost-effective method for flood-resilient housing that relies on locally available materials.

Case summary:

LSS, a mix of locally available soil, quicklime, sand, rice husk ash, and straw, enhances load-bearing capacity, resists erosion from heavy rainfall, and improves thermal comfort in cold winters. This technology can be tailored to Nepal's contrasting geoclimatic conditions—from earthquake-prone mountains to flood-prone plains. By applying the same LSS technology, this project has built earthquake-resilient demonstration houses in the mountain settlements of the Sinja Rural Municipality in Jumla district alongside flood resilient ones in the Banke district of the low-lying Terai plains. While the houses in Sinja were built using timber frames and stone masonry walls, finished with LSS plaster for walls, flat mud roofs, and floors, those in Banke were constructed as community halls with meeting and storage spaces, each 24' × 12' structure features a clear height of 9'4" and a two-way sloped roof.

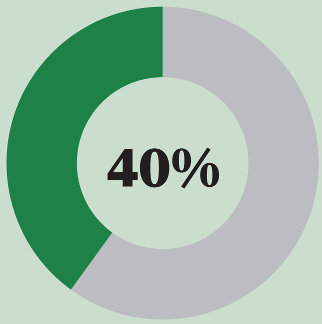
The design of the house in Sinja preserved Sinja's vernacular character while their flat mud roofs were upgraded with LSS layers for greater weather resistance, with stone masonry and detailed timber joinery for improved seismic stability.

To mitigate flood risk in the Terai planes, the buildings in Rapti-Sonari were elevated to 3 feet and in those in Duduwa to 5 feet and fitted with ramps for accessibility. While a Rapti-Sonari house uses a timber frame with timber batten walls, a Duduwa house incorporates a bamboo frame with bamboo mesh walls. Both apply LSS plaster made from quicklime, local soil, sand, rice husk ash, and brick dust. Soil suitability and mix ratios were verified through shrinkage, jar, and compression strength tests, followed by 28 days of curing to ensure strength, durability, and flood resistance.

Sustainability and resilience features:

- In both location the project used locally available materials such as stone, timber, and lime stabilized soil made from soil, lime, sand, and rice husk ash. This reduced dependence on high carbon materials like cement and steel, stabilised soil, increased thermal mass, keeping the houses warm in sub-zero winters and cool in summer, while lowering fuel use.
- Agricultural residue such as straw and rice husk ash was reused, reducing both waste and cost.
- In Banke, the LSS technology achieved a near carbon neutral cycle through lime carbonation. Vapor permeable lime plasters reduced dampness, molding, and decay while improving indoor comfort in humid conditions.

The project trained 18 masons and encouraged the construction of over 10 climate-resilient homes in Jumla



Application of LSS technology reduced construction costs by 40 % compared to cement mortar structures

- Timber frames and stone masonry, in the Jumla houses, were combined with LSS plaster for flooring and roofing to improve insulation, earthquake resistance, and durability against rain and frost. Flexible joints, raised roofs, and improved detailing reduced wind and seismic risks.
- LSS was applied in Terai's lowland context to strengthen flood prone earthen homes while maintaining affordability and traditional appearance. The structures were designed in line with the local community's wattle and daub tradition and required only basic lime stabilisation.
- Raised plinths, stabilised walls, and reinforced frames improved resilience to floods and earthquakes. LSS coatings protected against erosion and fire, extending building life with little maintenance.

Inclusiveness and scalability:

The project adopted a community-driven, partner-supported approach that maximised local resources, participation, and inclusivity:

- Use of locally available stone, timber, soil, sand, rice husk ash, barley husk ash, straw, and quicklime, reduced transport costs and emissions.
- With no need for heavy machinery, the process relied entirely on local labour and knowledge.
- Locally sourced materials and local labour reduced dependence on imported high carbon materials, created income opportunities in the community and made adoption easier.
- The construction period served as on-the-job training for the local masons and carpenters, who were trained in disaster-resilient construction methods and lime/soil stabilisation. Eighteen local masons received hands-on training alongside skilled carpenters and stone masons, combining traditional expertise with improved techniques.
- The approach blended local craftsmanship with modern testing of soil-lime ratios, ensuring cultural continuity and technical reliability.
- Female masons, women-headed households, and vulnerable households affected by past disasters were prioritised to promote inclusion. Women and marginalised groups were engaged in lime mixing, plastering, and quality control.

Consistent community engagement, trust building initiatives, and adapting the technology to local culture and context, the LSS technology can be scaled in disaster-prone areas:

- Local government leadership and community participation have been central to piloting and growing interest in LSS technology.
- The Sinja Rural Municipality provided co-financing and logistical support, and twenty additional houses are being built using the LSS technology, largely inspired by one demonstration house.

- Demonstration houses allowed communities to see its benefits in practice, leading to six households applying LSS plaster at their own cost.
- With small design and material adjustments, this model can be replicated across mountain settlements in Nepal to improve earthquake safety, climate resilience, and heritage preservation.

The project strengthened technical capacity, demonstrated low-cost, flood and earthquake-resilient housing, and reinforced local ownership of climate-adaptive building practices.

Challenges and key learning:

Jumla

- Variability in local soil quality affected the consistency of lime-soil rations for stabilisation. Field-based testing methods such as jar and ball drop tests helped adapt mix ratios to local conditions.
- Limited familiarity with stabilised soil construction was addressed through practical demonstrations, mentoring by experienced masons, and visual guides.
- The unavailability of bitumen waterproofing membranes highlighted the need for better supply linkages, as plastic sheets proved inadequate for long-term roofing protection. Weather-related disruptions were mitigated by flexible scheduling, advance material stockpiling, and the use of temporary sheds for lime curing.
- Women's participation initially faced social barriers, which were overcome by assigning roles in soil preparation, plastering, and quality checks, fostering inclusion and confidence.

Banke

- Due to variable soil quality, a single reliable source was selected, and all materials were tested to determine the optimal LSS mix.
- The reactive nature of lime posed handling and storage challenges:
    - Quicklime lumps were processed and stored locally under strict safety measures.
    - To ensure quality and safety, lime was crushed, stored in airtight containers, and mixed under protective supervision with proper gear.
    - Safety was emphasised using personal protective equipment and regular briefings.
- Limited local supply required vendor scoping to secure reliable sources.
- Soil variation across sites influenced structural performance, which was addressed through testing and the preparation of site-specific mix tables.
- The project also emphasised on material durability-seasoned timber was used for longevity, and locally available bamboo was chemically treated with boric acid and borax to prevent pest and fungal damage in flood-prone environments.

Outcomes and impact:

The project in Jumla trained 18 masons and spurred the construction of over 10 climate-resilient homes using natural local materials such as stone, timber, stabilized soil, sand, straw, and ash. It reduced cement use, reduced carbon emissions, and reused agricultural waste. The project also revived Indigenous building knowledge, improved thermal comfort during winter, and empowered women through hands-on learning. Using local materials and low-cost techniques lowered construction expenses, making safe housing more accessible to the vulnerable families. The visible success of demonstration homes built community confidence and secured municipal support, creating a model for resilient mountain housing across the Himalayas.

In Banke, CRS Nepal piloted two demonstration houses during the monsoon, proving the effectiveness of lime-stabilized soil technology for flood resilience. This method reduced construction costs by 40% compared to cement mortar while maintaining strength and durability. Active involvement from local governments and communities helped ensure the approach was culturally appropriate, climate-resilient, and scalable through local capacity building.

18

Bamboo Houses: Disaster Resilient, Sustainable and affordable Housing

Nepal

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Background:

After the devastating 2015 earthquake in Nepal, the need for disaster resilient, safe and durable housing became even more important. Nepal's annual housing demand is estimated at 136,000 units, while construction meets only 102,000 units. The annual shortfall of 34,000 units is primarily due to affordability challenges, forcing many poor and marginalised families to live in substandard conditions. Nearly 47% of the country's 6.7 million homes are considered inadequate or unsafe. Moreover, the manufacturing and construction sectors account for 48% of total CO_2 emissions of Nepal, with the brick and cement industries contribute to around 84% of emissions within these sectors. To address these challenges, Habitat for Humanity Nepal is promoting Cement Bamboo Frame Technology (CBFT) as a sustainable, nature-based solution to ensure safe and dignified housing for all.

Case summary:

CBFT housing technology is an innovative, nature-based, low-carbon solution that uses scientifically treated local bamboo and is designed according to the international standards (ISO 22156, ISO 22157, ISO 19624). The system employs composite shear panels made of a wall matrix of flattened bamboo and chicken wire mesh, fixed onto a bamboo or sawn timber frame, plastered with cement mortar render. This results in an affordable and disaster-resilient structure, while also improving indoor thermal comfort. The technology can be hybridised with other sustainable materials such as CSEBs, providing communities with more design options. A typical CBFT house with two rooms, a kitchen, a toilet, and a veranda, covering 31.5 m^2 and accommodating five family members, has a carbon footprint of 6.1 tons or 94% lower than a Reinforced Cement Concrete (RCC) structure and 86% lower than a brick building.

The project is implemented through a collaborative effort involving Habitat for Humanity Nepal, the Department of Urban Development and Building Construction (DUDBC), Government of Nepal, local governments, and partner NGOs.

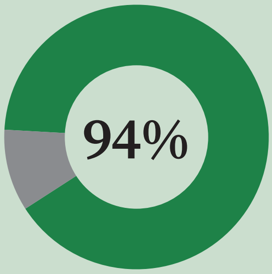
Sustainability and resilience features:

- CBFT relies on locally available bamboo treated through a low-energy, eco-friendly process using boric acid and borax, ensuring durability of at least 35 years without environmental harm.
- Bamboo serves as the primary load-bearing component, replacing carbon-intensive materials like bricks and steel. It sequesters up to 60 tons of CO_2 per hectare per year, supports biodiversity conservation, prevents soil erosion, and provides fodder and food for livestock.

- Construction costs are lower than conventional RCC or brick masonry houses, and bamboo-based housing also builds on Nepal's longstanding traditions of bamboo use.
- Mud plastered interiors improve thermal comfort compared to brick masonry. Thermal design reduces the need for artificial heating and cooling, while biodegradable, locally sourced materials minimise waste.
- Treated bamboo resists pests and decay, while its natural ductility provides earthquake resilience. Elevated foundations protect against floods and landslides, and cement plaster enhances durability against high winds and fire.
- The construction and maintenance of CBFT houses are simpler and more manageable than conventional designs, while after disaster, these houses can be repaired quickly and affordably.
- CBFT houses combine modern engineering with traditional knowledge from local masons and labourers, making the technology affordable and culturally relevant.

Inclusiveness and scalability:

The project ensures a gender- and socially inclusive approach. Women and marginalised groups are engaged throughout the construction phase, receiving dedicated training in sustainable techniques at the project sites, which strengthens their technical skills, generates new



94% lower carbon footprint than RCC and 86% lower than brick masonry for similar size

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44% cheaper than RCC/brick masonry homes (NPR 450,000 vs. NPR 800,000)

667

houses built since 2021

livelihood opportunities, improves their economic status, confidence and decision-making ability. This promotes economic empowerment and helps challenge traditional barriers in homebuilding.

This involvement but also ensures community ownership. With GESI as a core principle, the project promotes equitable participation, benefiting women and marginalized groups alongside the wider community.

Since bamboo construction is rooted in Nepal's traditions, communities already participate in bamboo harvesting and treatment and use it for both construction and non-construction purposes. CBFT strengthens this heritage by integrating scientific treatment, structural resilience, and inclusive training, ensuring designs remain culturally accepted, replicable, and scalable across Nepal. Since 2021, a total of 667 houses has been built, with the number increasing each year.

Key success factors for scaling CBFT include the engagement of local and provincial governments, active community participation, mason training, private sector involvement, and the use of nature-based materials. Affordability, cultural sensitivity, a low carbon footprint, resilience, and sustainability further strengthen its potential for replication.

In mountain areas, CBFT can be adapted to local bamboo species, climate conditions, and cultural practices. Building the capacity of construction workers and establishing bamboo treatment centres are essential steps. With government support and integration into local supply chains, CBFT can be scaled as a viable and eco-friendly housing solution across diverse mountainous and other regions

Challenges and key learning:

Promoting CBFT has faced several challenges that offer key lessons for wider adoption:

- Bamboo is still perceived as a "poor man's material," with bamboo houses often dismissed as temporary or low-quality shelters. This stigma, combined with limited awareness of the resilience and sustainability of bamboo structures, underscores the need for awareness campaigns, demonstrations, and visible proof of durability.
- Policy and regulatory gaps also constrain uptake, as bamboo is not yet fully integrated into national housing policies, building codes, or technical guidelines. While Habitat Nepal is supporting the Ministry of Urban Development to prepare bamboo guidelines and ISO standards, sustained advocacy with government agencies and policymakers remains essential.
- A shortage of skilled labour trained in CBFT techniques poses another barrier, emphasizing the importance of local training programs to expand technical capacity. Research on bamboo construction is also limited in Nepal and globally, highlighting the need for stronger collaboration with academic and research institutions to generate evidence for advocacy and technical credibility.

Together, these challenges show that shifting perceptions, strengthening policy frameworks, expanding skills, and building evidence are all critical to scaling CBFT as a resilient and sustainable housing solution.

Outcomes and impact:

Using bamboo and other low-carbon materials, CBFT can significantly reduce the annual housing deficit by providing affordable, resilient, and sustainable homes that contribute to climate change mitigation. Socially, it offers safer shelters for poor and marginalised communities, improving their living conditions and providing more dignified housing, while empowering residents through skills training for participating in new employment and income opportunities. Economically, CBFT lowers construction costs and creates local employment opportunities. Overall, the approach strengthens community resilience, raises living standards, and supports sustainable development and climate goals.

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Rethinking the traditional 'Machang House' through Ecosense Resort in Bandarban

Bandarban, Chattogram Hill Tracts, Bangladesh

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Background:

The Chattogram Hill Tracts (CHT) is a vast hilly region in southeastern Bangladesh, comprising three districts: Bandarban, Rangamati, and Khagrachhari. Amidst the lush greenery of these remote areas, vernacular houses known as Machang houses continue to serve several Indigenous communities in the hills.

Case summary:

An example of the *Machang* house is demonstrated through a built project in the CHT, Bangladesh. The Ecosense Resort in Nilachal, Bandarban, an eco-friendly resort located just a five-minute drive from Bandarban city, has been selected for this case. The project preserves the essence of local tradition and culture by showcasing century-old *Machang* huts to visitors as part of community-based tourism.

Sustainability and resilience features:

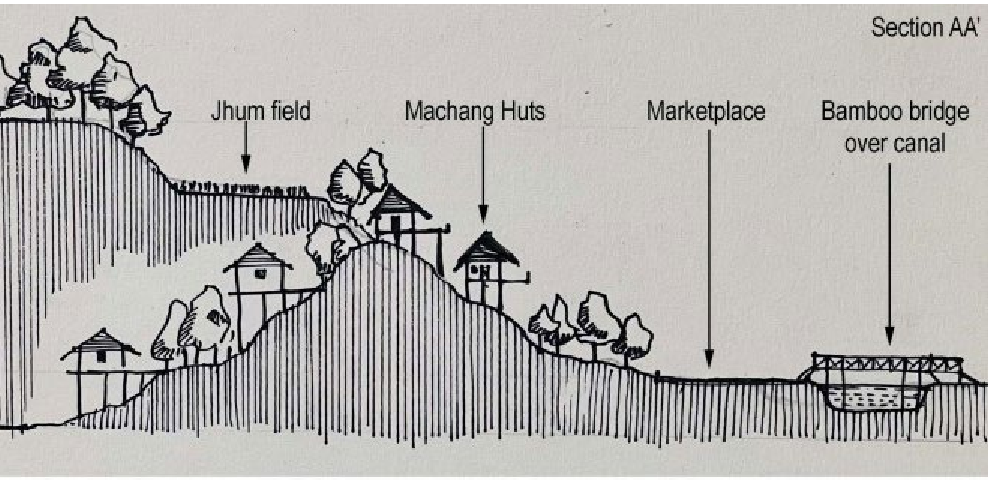
Since 2015, the site has evolved as Indigenous groups established community-based settlements, known as *paras*, around the resort. The resort design respects this concept, consisting of clustered *Machang* cottages for both nuclear and extended families.

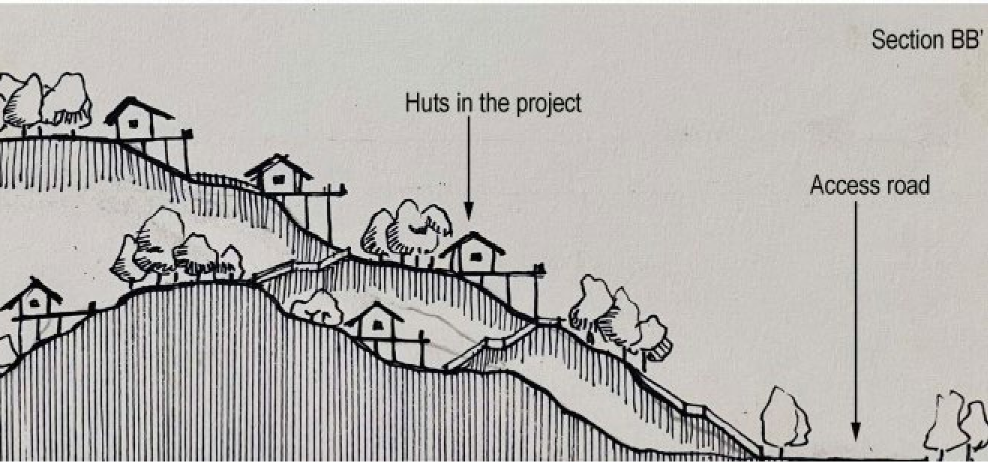
The cottages follow the contour lines, ensuring access to the Bandarban Highway and connecting at different heights through walkways and staircases that lead to shared dining spaces.

Following indigenous spatial planning, houses are built on midland areas, while agricultural fields are located on hilltops for better sunlight. For example, the Mro community traditionally settles deep in the forests on high hills, a practice that brings both cultural continuity and daily challenges. Positioning structures according to the topography also enhances resilience during natural disasters.

The use of locally available materials and inherited construction techniques lowers costs and reduces environmental impacts. However, access to basic services such as water and electricity becomes difficult at higher altitudes. Communities depend on streams connected by NGO-installed pipelines with limited government maintenance. But they face water shortages in dry seasons due to the absence of reservoirs or water conservation systems.

Despite recurring disasters such as earthquakes and landslides, indigenous construction knowledge has long provided resilience. Bamboo is the main building material, offering seismic resistance, affordability, and durability while blending with the natural environment. Its use minimises carbon footprint, allows rainwater absorption, and avoids the ecological damage of heavy construction. Lightweight bamboo and timber stilts reduce inertial loads during





earthquakes and mitigate water and soil pressure during landslides. Architecturally, bamboo also ensures natural cooling and comfort in summer while preserving the hills from further degradation.

Inclusiveness and scalability:

The project encourages community participation in tourism initiatives that embrace their tradition and culture. The primary objective is to offer tourists an authentic experience of Indigenous traditions, with locals involved in both construction and guest services.

- This approach preserves community identity, provides employment opportunities, and minimises project expenses.
- Costs are further reduced by using vernacular construction techniques and local labour with expertise in traditional methods. Engaging the community ensures sustainability by providing stable income while allowing smooth project operations.
- Additionally, the project inspires investors to promote the culture and traditions of hilly region communities, often overlooked and underserved.

By implementing nature-based, disaster-resilient solutions with minimal environmental impact, the project demonstrates the potential for innovation in construction and sustainable tourism practices.

The architecture of the traditional Machang houses and the spatial planning has multiple scopes of scaling / replication:

- In tropical regions, the concept of such houses built with local natural materials and construction techniques can function perfectly since these houses can be used as portable huts due to the use of poles and each compartment can be customised if required.
- Additionally, the utilisation of bamboo poles and non-structural woven partition walls makes the spaces flexible with the compartments designed as modules that can be expanded, as required, by adding structural poles as per the modules.

Challenges and key learning:

Modern building materials and economic interactions with local settlers have contributed to the decline of traditional Machang houses, as communities increasingly adopt tin and brick constructions, putting Indigenous architectural heritage at risk. The project demonstrates that tourism can help revive these structures by encouraging visitors to stay in Machang cottages, creating cultural appreciation and demand.

Integrating Indigenous knowledge with modern facilities poses challenge, as houses built entirely from local materials have limited lifespans and require frequent repairs. The project addressed this by incorporating selective modern materials, such as metal poles for foundations and trusses for roofs, extending durability while preserving traditional techniques. This blend of traditional and modern methods provides a practical model for sustaining and reviving cultural architecture in a contemporary context.

Outcomes and impact

The project demonstrates clear environmental and social benefits. Using traditional construction methods draws attention to local culture and natural resources, reducing economic costs and minimising environmental impact. The approach also lowers the project's carbon footprint. Additionally, the tourism-based initiative creates income opportunities for local residents and stimulates economic growth in the surrounding communities.

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Disaster-Resilient, Two-Storied Community Distribution Point

Cox's Bazar, Bangladesh

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Background:

The two-storied community distribution point in the Rohingya refugee camp, Cox's Bazar, Bangladesh, was funded by the Danish Refugee Council to serve as a storage and distribution hub for shelter materials and non-food items. Situated in a hilly area where permanent structures are prohibited, it employs an innovative, lightweight design using treated bamboo. Combining traditional bamboo techniques with modern engineering, the structure is resilient to landslides, heavy rain, and cyclones. The project demonstrates how nature-based, low-carbon solutions can provide safe, functional humanitarian infrastructure in temporary, hazard-prone, and resource-constrained contexts.

Case summary:

The building was constructed using treated Borak bamboo (Bambusa balcooa) sourced from the Danish Refugee Council's bamboo treatment plant, ensuring compliance with the Bangladesh National Building Code-2020 for structural use. Recyclable prefabricated steel pad footings prevented direct soil contact. Columns and beams, made from bundles of two to four bamboo poles, transferred loads to the foundation, with lapped joints and connections designed according to BNBC-2020 standards. Walls were half-clad with Muli bamboo (Melocanna baccifera), arranged alternately for stability and ventilation. Borak bamboo formed rafters, purlins, and roof trusses, with bamboo mat and tarpaulin used for roof cladding. Additional wind resistance was provided by bamboo bracing tied with 6-inch rope. This combination of nature-based materials and modular techniques resulted in a durable, disaster-resilient, and environmentally friendly structure suitable for the Rohingya refugee camp.

Sustainability and resilience features:

- This two-storied community distribution point demonstrates sustainable, low-carbon, and context-sensitive design.
- Constructed primarily from locally sourced Borak bamboo (Bambusa balcooa) treated to meet BNBC standards, the structure reduces embodied carbon compared to concrete or steel.
- Walls feature half-cladding of Muli bamboo (Melocanna baccifera) for natural ventilation and daylighting, while roof overhangs and orientation minimise solar heat gain.
- Prefabricated steel pad footings prevent soil contact and support modular construction; ehilr engineered bamboo joints, rope bracing, and roof anchoring provide resilience against cyclones, heavy rain, landslides, and high wind loads.

- Residual bamboo was repurposed for ventilation mats and roof cladding.
- Rainwater harvesting was integrated for water conservation.
- The design blends Indigenous bamboo craftsmanship with modern engineering, ensuring durability, energy efficiency, and disaster resilience.

Inclusiveness and scalability:

Gender-inclusive features include accessible entry points, separate collection areas for women and the elderly, and women-friendly spaces, with community involvement through skill building in sustainable construction.

Women and vulnerable community members were actively involved in construction and decision-making, promoting skill transfer and fostering ownership.

Design features ensured accessible circulation and safe spaces for all users, supporting inclusivity.

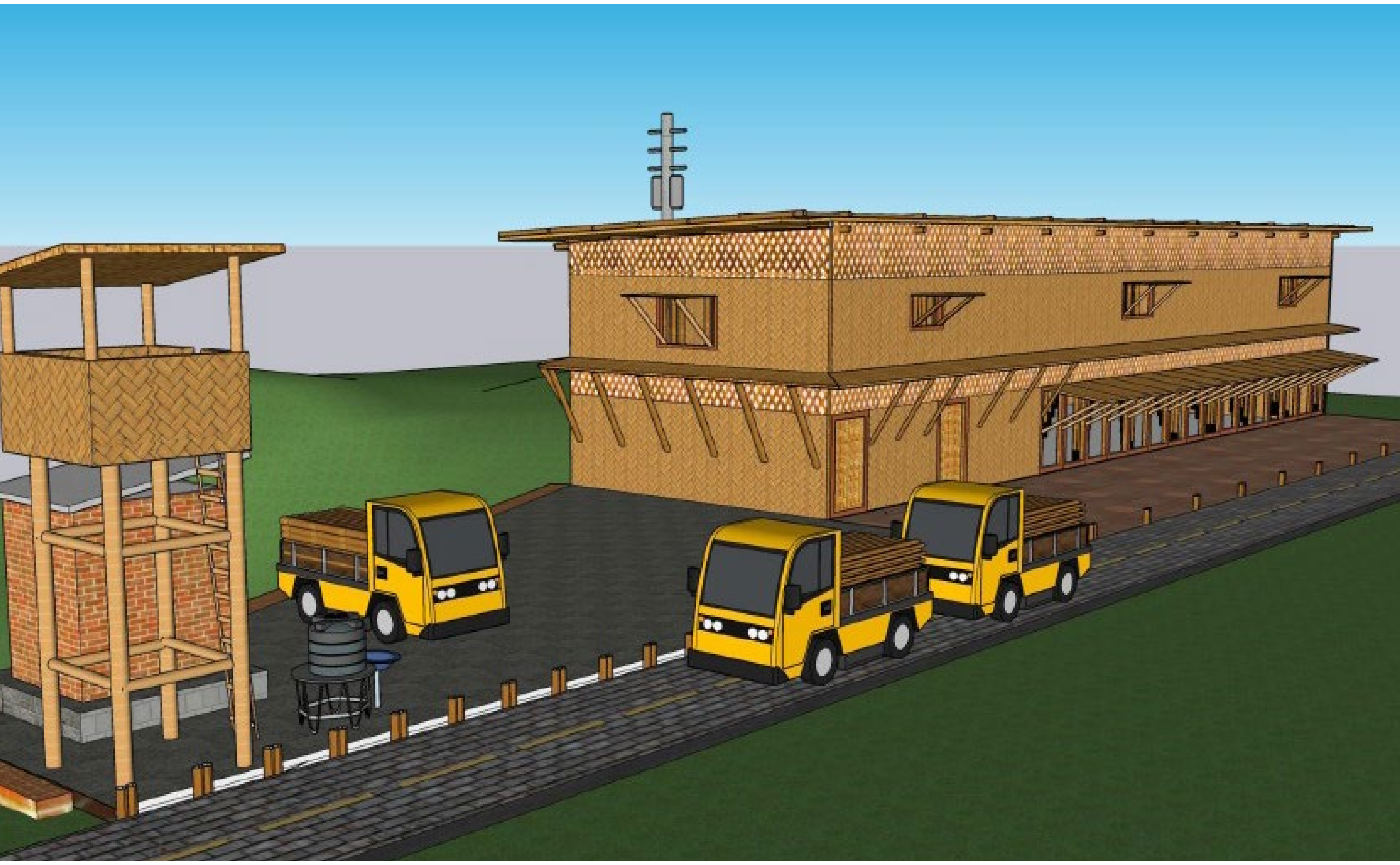
Hands-on engagement and visible social impact reinforced motivation, while the innovative use of treated bamboo highlighted the potential of nature-based, culturally appropriate solutions.

The project team was guided by a commitment to climate-resilient, low-carbon infrastructure in a high-risk, temporary settlement with the project demonstrating how low-carbon, nature-based, and culturally appropriate methods can deliver resilient, temporary infrastructure in hazard-prone, resource-limited contexts.

Critical success factors of the project include the use of treated, locally sourced bamboo, engineered bracing and roof anchoring for wind resistance, modular prefabricated steel footings, and community engagement with GESI-sensitive practices.

The integration of Indigenous bamboo craftsmanship with modern engineering ensured structural resilience, affordability, and sustainability. These solutions are contextually adaptable.

Similar bamboo species and treatment methods can be used in other mountain settlements, while modular design allows relocation or expansion. Community-led construction and inclusive participation provide social ownership, making the model replicable, scalable, and climate-resilient for temporary or hazard-prone settlements across the region.



Challenges and key learning:

The project highlighted the importance of lightweight and resilient design in temporary, government-restricted settlements on hilly terrain. High wind, heavy rain, and landslide risks require robust structural solutions, while limited local skills in engineered bamboo construction emphasised the need for capacity building and skill transfer.

Ensuring social inclusivity, particularly engaging women and vulnerable groups, adds complexity but strengthens community ownership.

Nature-positive, affordable solutions such as treated Borak bamboo, rope bracing, and prefabricated steel pad footings reduce carbon footprint, minimise waste, and support modular assembly. Half-clad Muli bamboo walls enhance ventilation, passive cooling, and lightweight load distribution, contributing to overall disaster resilience.

Outcomes and impact:

The two-storied bamboo distribution point provides multiple benefits.

- Environmentally, it lowers carbon footprint using renewable bamboo and modular steel footings while promoting passive cooling and ventilation.
- Socially, it strengthens community resilience, ensures safe access for women, children, and vulnerable groups, and builds local skills through participatory construction.
- Economically, the lightweight, locally sourced materials and modular design reduce construction and maintenance costs, creating an affordable, durable, and replicable model.

Overall, the project illustrates a climate-resilient, low-carbon, and socially inclusive approach suitable for temporary, high-risk settlements.

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