Lobitos & Piedritas Humanitarian Design Challenge

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This document highlights Adrian Montenegro's individual contributions. The original Engineering for People Design Challenge was completed collaboratively.

Abstract

Lobitos and Piedritas are two small coastal communities in northern Peru facing aging housing, limited basic services, and growing risks from El Niño–related flooding. Their economies rely heavily on artisanal fishing and small local businesses, leaving many families vulnerable to environmental and economic pressures. This project, completed for the Engineers for People Design Challenge, develops a modular housing concept that improves durability, thermal comfort, affordability, and hazard resilience while staying grounded in local culture and construction practices. Our approach includes site analysis, community input, clear design criteria, comparative material assessment, and an Envision-based sustainability review. The goal is to deliver a practical and scalable design that strengthens day-to-day living conditions and supports long-term, sustainable development in both communities.

Challenge

Northern Peru's Pacific coast is shaped by narrow desert plains, rocky cliffs, and small river valleys. Lobitos and Piedritas sit in the Piura region, where temperatures reach 25–32 °C and annual rainfall is under 100 mm. During strong El Niño cycles, rainfall can spike dramatically, bringing floods, landslides, and service disruptions. These shifting conditions influence how people build, what materials last, and which strategies support long-term resilience. The surrounding dry forest—important for biodiversity and natural flood buffering—continues to face pressure from development and land-use change.

People and livelihoods. Lobitos has a mix of tourism, surf schools, small restaurants, and older homes from the oil boom. Piedritas is more rural, with families relying on fishing, animal keeping, small shops, and informal construction work. Many households juggle multiple jobs to manage economic uncertainty. Women frequently lead community initiatives, including greening projects and youth programs, reflecting strong social networks and informal leadership.

Current built environment challenges. Many homes remain vulnerable to desert conditions: corroding roofs, informal plots, limited sewerage, and exposure to flooding. Nearby tourism hubs show the risks of unmanaged development—waste overflow, shoreline erosion, and pressure on water resources. These issues mirror EcoSwell's priorities: water scarcity, ecosystem protection, and community-driven, low-impact growth.

Case study insights. Interviews highlight common needs. In Lobitos, residents seek better public spaces, transport facilities, and upgraded surf-school and educational infrastructure. In Piedritas, priorities include multi-use community buildings, reforestation, and improved water access. These perspectives reinforce EcoSwell's focus on designs that strengthen social cohesion, protect natural systems, and support sustainable livelihoods.

Empathy and analysis. Following the competition's "analyse the context" guidance, we reviewed interviews, community stories, and environmental data to understand root causes of housing vulnerability, water stress, and spatial inequity. This process clarified the criteria for a successful design: climate resilience, durable materials, cultural appropriateness, water-conscious construction, and alignment with EcoSwell's mission of supporting communities through sustainable, locally driven development.

Figure 1: Lobitos & Piedritas regional map showing settlement patterns and terrain.

Design

The competition framework encourages teams to ”define the problem and criteria for success” by considering social, environmental and economic objectives. In our project, we first identified basic needs and constraints: safe shelter, thermal comfort, affordability, hazard resilience and community empowerment. We then organised the design areas into categories inspired by the challenge brief: Built Environment, Water, Sanitation, Energy, Waste, Food, Digital and Transport. For each area we recorded opportunities and constraints:

- **Built Environment:** housing quality varies from 100-year-old wooden houses to recent brick and plywood structures. Many new developments lack sewer connections and grid access. The tourism boom has driven rapid expansion, but poorly sited buildings have caused shoreline erosion and wave degradation.
- **Water:** Water scarcity is acute; piped water arrives only a few hours on certain days and households rely on rooftop tanks or expensive bottled water. Groundwater is brackish with high chlorides and coliforms.
- **Sanitation:** There is an abandoned wastewater system and combined sewer lines leak, creating wastewater pools and health hazards. Many homes in Lobitos and Piedritas resort to soakaways or open defecation.
- **Energy:** Households are mostly off grid; some rely on informal connections or diesel generators. Opportunities exist for small-scale solar and improved energy efficiency.
- **Waste:** Solid waste management is limited; poorly managed tourism in other towns has caused waste and sanitation crises.
- **Food:** Agriculture is minimal due to the desert climate, but greywater reuse for plantings has been piloted in 60 families in Lobitos and 20 families in Piedritas.
- **Digital:** Limited internet access constrains education and commerce. Case studies mention a need for better connectivity and educational facilities.
- **Transport:** Darío calls for improved bus stops and public spaces; roads and pedestrian infrastructure must accommodate tourism and local mobility.

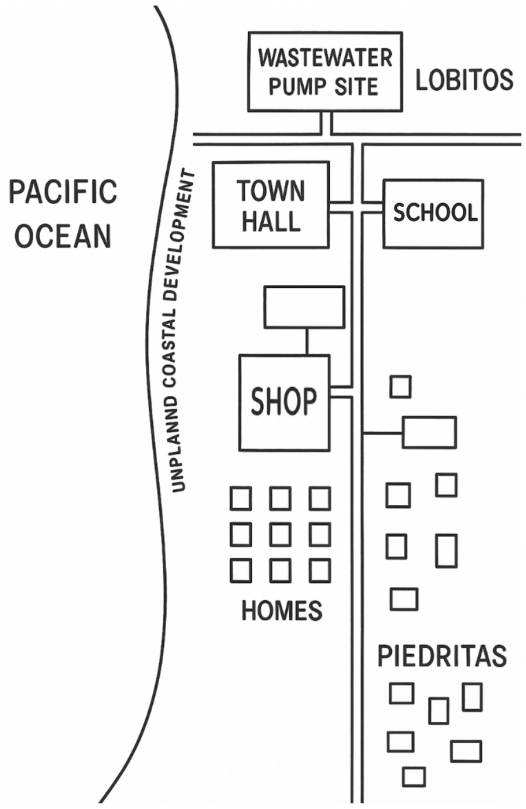

Figure 2: Comprehensive design overview showing the integrated approach to housing, infrastructure, and community spaces in Lobitos.

Feasibility and precedence. We studied regional construction typologies to inform our approach. Traditional homes in Lobitos use

wooden frames with plywood walls and corrugated iron or tin roofs; newer structures employ bricks or concrete with corrugated iron. In Primavera and Nuevo Lobitos, many houses are simple plywood or brick structures on small plots. Community experience with stilted homes along the coast and the use of concrete pads in nearby villages inspired our elevated foundation concept. We also drew lessons from Los Órganos, a nearby town that effectively managed waste and preserved its natural environment.

Proposed design concept. Our modular housing system addresses the identified categories. Key features include:

1. **Elevated timber/bamboo frame:** posts on concrete pads raise the house above flood levels and mitigate termite and moisture damage.
2. **Durable cladding:** corrugated steel or alu-zinc panels provide corrosion resistance and long service life. A 25 mm air gap filled with natural fibre insulation improves thermal comfort.
3. **Passive cooling:** orientation and roof overhangs maximise shading and ventilation; cross-ventilation reduces internal temperatures.
4. **Off-grid upgrades:** the design can incorporate solar panels, rainwater harvesting and composting toilets as add-ons to address energy, water and sanitation.
5. **Community participation:** training workshops enable residents to build and maintain homes, strengthening ownership and economic opportunities.

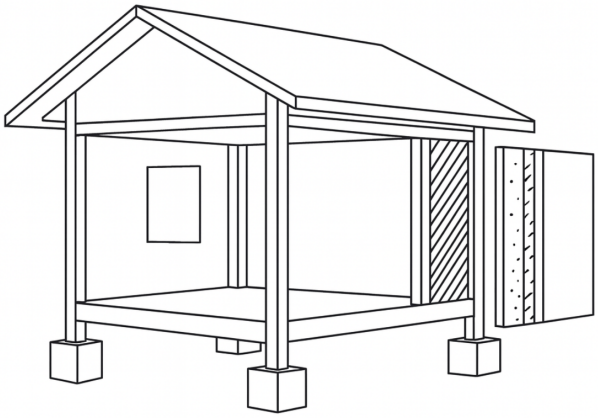

Figure 3: Conceptual schematic of the elevated foundation, modular frame, and layered wall system.

Materials & Selection

Material selection balanced cost, durability, and sustainability. Local buildings typically use plywood (decays in 7-12 years) and corrugated iron (rusts quickly). Our analysis compared these against improved alternatives.

Material	**Cost (S/m²)**	**Service Life**	**LCC**	**COe**	**Key Characteristics**
Existing:					
Plywood (20mm)	140-190	7-12 yrs	High	Low	Affordable but decays rapidly
[2pt] Corrugated iron	150-200	10-20 yrs	Medium	Low	Rusts in coastal environment
[2pt] Brick/concrete	-	50+ yrs	High	High	Poor thermal performance
[4pt] *Proposed:*					
Galvanised steel	160-280	25-40 yrs	Medium	30-40 kg	Balanced cost and durability
[2pt] Alu-zinc steel	200-310	40-60 yrs	Low	35-45 kg	Salt-resistant, longest life
[2pt] Bamboo	100-150	10-20 yrs	Medium	Very low	Local material, labor intensive

Selection Rationale

Evaluation considered cost (40%), durability (30%), carbon (20%), and local fit (10%). Galvanised steel offers optimal balance—affordable, durable, and recyclable. Alu-zinc provides superior corrosion resistance for exposed locations. Bamboo complements as interior/cladding material.

Envision Rating

Category (weight)	Key Criteria	Design Response	Score
Quality of Life (22%)	• Community well-being • Health and safety • Daily comfort	• Elevated flood-resistant housing • Passive cooling and ventilation • Improved sanitation • Walkable layout	80%
Leadership (15%)	• Community collaboration • Local capacity building • Stakeholder engagement	• Co-design workshops • Regular stakeholder meetings • Construction training	85%
Resource Allocation (23%)	• Local materials • Low-impact resources • Modular design	• Bamboo and earth masonry • Recyclable steel framing • Solar and rainwater systems	70%
Natural World (25%)	• Floodplain protection • Habitat conservation • Site ecology	• Elevated above floodplain • Native landscaping • Runoff management • Living roofs	60%
Climate & Resilience (15%)	• Emissions reduction • Climate adaptation • Hazard resilience	• Passive cooling • Cross-ventilation • Flood-resistant structure • Corrosion-resistant materials	80%

Overall estimated performance: 75% of applicable points, achieving Platinum-level rating for conceptual design.

Conclusion

Our competition submission dissects the context of Lobitos and Piedritas, defines a problem grounded in basic needs and hazard resilience, explores multiple design areas and justifies the chosen solution through comparative material assessment and Envision benchmarking. By immersing ourselves in the community's history, economy and environment, we empathised with residents and defined success criteria that balance social, environmental and economic objectives. The modular housing design—involving elevated timber or bamboo frames, durable steel cladding, and passive thermal control—was informed by local case studies and analogous infrastructure. The comparative table highlights why corrugated steel and alu-zinc panels outperform plywood and corrugated iron in the saline, flood-prone coastal environment. Using Envision, we demonstrated qualification in quality of life, leadership, resource allocation and climate resilience. In short, this project presents a legitimate, comprehensive response to the humanitarian design challenge—one that could be implemented and adapted by the community to build a more resilient and inclusive future.