Vaka ni Lomani

1. Concept Narrative

In the heart of Naviti Island, where the mountains meet the sea and the sky cradles the land, the people of Marou wake each day to the rhythm of tide and song. Here, life has always flowed with nature — the rain that nourishes the crops, the sun that warms the earth, the streams that whisper their stories down the slopes. Vaka ni Lomani — *the Vessel of Compassion* — is born from this sacred connection.

At the heart of the design is an open, multifunctional space — a solar array shaded gathering place inspired by the Fijian concept of solesolevaki (working together). This space serves as a hub for communal life: recreation, dance, ceremonies, and collective resilience-building.

The Pavillion is the centerpiece of a larger pumped hydro energy storage system, and acts as the opening to a water filtration and underground storage reservoir to serve the community's needs - seamlessly blending renewable infrastructure and traditional communal ways of life.

The energy system is multi-layered:

- A small pumped hydro system is fed by the refurbished dam, which captures and stores stormwater runoff, providing not only electricity generation but also vital services such as flood protection and drinking water storage.
- A combined solar-water nexus pavillion that generates energy, and provides multi-stage water collection and purification, including three species of native biofilters embedded in the open channel.
- Rooftop solar PV systems installed on residential buildings and the community centre contribute decentralised generation while enhancing self-sufficiency.
- Battery Energy Storage Systems (BESS) ensure stable energy availability, particularly in the evenings and early mornings, which matches the anticipated daily demand curve.

Co-benefits of the system include:

- Reliable access to clean electricity and drinking water year-round.
- Reduced vulnerability to climate impacts such as droughts and floods.
- New opportunities for economic activities like cold storage for fish, small-scale food production, and tourism.
- Enhanced education and health outcomes through reliable power for schools, clinics, and communication systems.
- Technical upskilling for local high schoolers to participate in care & maintenance for renewable energy system.
- Revitalisation of cultural practices through the creation of shared spaces that foster community cohesion.
- Opportunity to co-create storytelling element of tapa-cloth style engraving on Pavillion floor with local artisans and carvers.

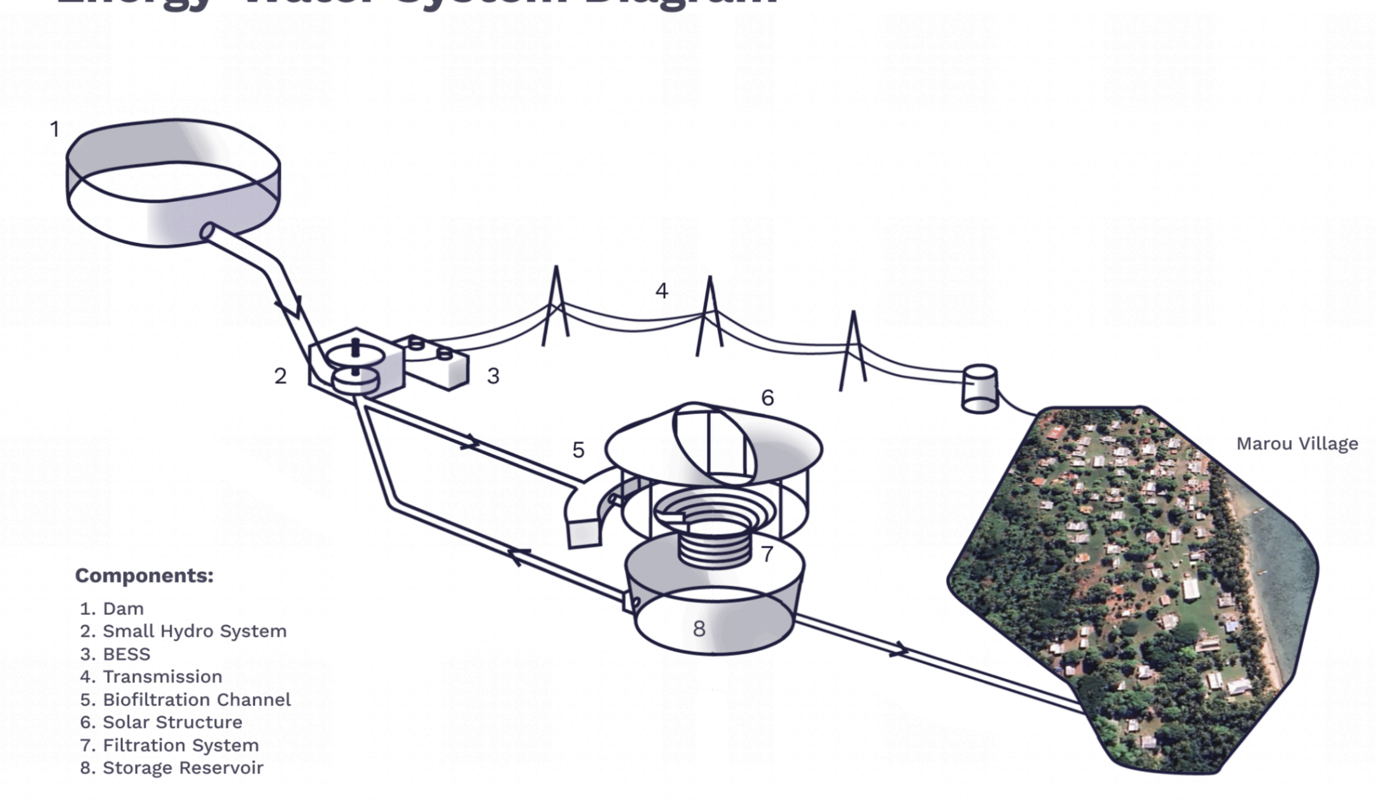
Ultimately, *Vaka ni Lomani* is a living, breathing infrastructure — a vessel carrying Marou Village and future generations towards a dignified, self-sufficient, and resilient future, in harmony with the land, the ocean, and the sky.

2. Technical Narrative

The proposed system integrates three primary technologies — small hydro, solar photovoltaics, and battery energy storage systems (BESS) — supported by integrated rainwater harvesting and stormwater management solutions. The technology is selected based on commercial maturity, cost-effectiveness, transportation to the island, low maintenance, and technological longevity (long lifespan).

The total electricity capacity to meet demand is 95 kW and 300 kWh storage. The total water harvest to meet demand is 600,000 litres per year. Further details can be found in the table below, *"System inputs and outputs"*.

Energy-Water System Diagram



Small Hydro System

A micro-hydropower system is installed first by revitalising the village's old dam infrastructure. Stormwater from the mountainous catchment is stored in the dam and channelled through a low-head micro-hydro turbine system (~15 kW capacity) to the Channel Reservoir. This provides continuous base-load power, particularly during the rainy season when solar output is reduced, reducing battery reliance.

Solar Photovoltaic (PV) System

The solar PV installation consists of two complementary components:

- The Solar Pavillion: 50 kW of ground mounted solar array in a parametric arrangement creates the shade structure of a new community building.
- Rooftop Solar Systems: Approximately 30 kW of distributed solar panels are installed on key community buildings, including the recreation centre and selected residential homes.

Combined, the system exceeds the required 75 kW minimum PV capacity, ensuring ample daytime energy production while offering modular expansion possibilities.

Battery Energy Storage System (BESS)

A centralised lithium iron phosphate ($LiFePO4$) battery bank (~300 kWh usable capacity) provides electricity overnight and in the early morning. The sizing ensures:

- Nighttime energy availability (peak evening loads around 11–16 kW).
- Backup capacity for at least 1.5 days of autonomy during extended cloudy periods.

Water Systems:

Rainwater Harvesting and Storage

All solar panel surfaces are optimised to collect rainwater into first-flush filtered storage tanks, feeding into the Storage Rservoir.

- Solar Structure Rainwater Harvesting Area: ~400 m² of solar panel surface yields approximately 600 liters per 10mm rainfall event.
- Storage Reservoir: An underground HDPE water tank of ~200,000 litres exists under the Solar Structure, supplementing existing village tanks and Reservoir 2 capacity.

Water Treatment

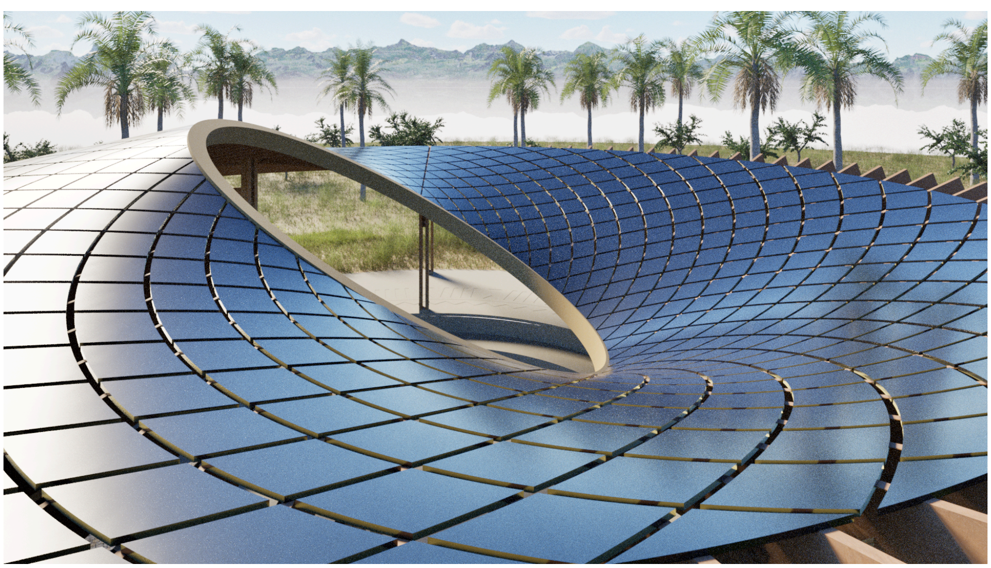
Simple nature-based filtration systems (e.g., gravel-sand filters) and biofilters are feature around and in the pavillion.

- Discharge from the dam offloads stormwater into the Channel Reservoir, where it is filtered by native species of Vetiver Grass, Canna Lily, and Water Hyacinth.
- This water, joined by the water collected by the Pavillion roof, are collected into the center of the staircase structure, paved by a permeable concrete, into a Filtration System, which takes the water through increasingly fine gravels, and then into a passive desalination membrane layer [1], and carbon filter, to make the water potable
- Potable water is then stored in an underground cistern, 'The Storage Reservoir', for use by the village.

Stormwater Management and Household Water Supply

- The Dam, Biofiltration Channel, and Storage Reservoir act as critical stormwater detention basins, reducing flood risk during heavy rains.

- Gravity-fed pipelines and solar-powered pumps convey water from the Storage Reservoir for agricultural use, household needs, and fire safety.



[1] https://www.researchgate.net/publication/311664498_Development_of_a_Desalination_Membrane_Bioinspired_by_Mangrove_Roots_for_Spontaneous_Filtration_of_Sodium_Ions

System Inputs and Outputs

Component	Input	Output
Small Hydro	Stormwater runoff	10–15 kW continuous renewable electricity
Solar PV Systems	Solar radiation (~4.5–5.5 kWh/m²/day)	75–80 kw peak renewable electricity
BESS	Surplus solar + hydro electricity	~300 kWh night-time and backup energy
Rainwater Harvesting	Rainfall (~1,500–2,500 mm/year)	~600,000 litres/year additional harvested water
Stormwater Management	Excess rain and runoff	Flood reduction, agricultural irrigation, and potable water
Water Treatment	Collected rainwater	Potable water, washing, and agricultural irrigation

3. Prototyping and Pilot Implementation Statement

Our team's approach to prototyping and pilot implementation prioritises community partnership, practical testing, and progressive scaling to ensure that *Vaka ni Lomani* is not just built *for* Marou Village, but *with* them at every step.

Prototyping Phase

The first step will involve constructing a scaled working prototype of the integrated solar PV, rainwater harvesting, and BESS system on a smaller plot, alongside a micro-hydro test rig based on the existing water flow potential of the Channel & Storage Reservoirs.
This prototype will be developed at a the designated test site in Suva to:

- Validate system sizing against Marou's hourly demand curve.
- Field-test cyclone resilience measures (anchoring, tilt adjustments, water drainage).
- Optimise construction techniques, transport logistics, and modular connections suited for the Yasawa Islands' realities.
- Validate water safety/potential desalination requirements, traditional versus experimentation purification technologies, and staging.

Prototyping will focus on:

- Modular agrivoltaic solar frames using cyclone-resistant yet lightweight designs, incorporating local bamboo.
- First-flush rainwater filtration integrated beneath solar panel arrays.
- Simple plug-and-play hydro and battery interfaces minimise operational complexity.
- Community-friendly controls using intuitive, visual indicators and training materials.

Hands-on involvement of Fijian technical students, village representatives, and young engineers will be prioritised during this stage, helping build early skills and ownership

Pilot Implementation in Marou Village

Following successful prototyping, the complete pilot will be deployed to Marou. The implementation process will include:

- Pre-installation workshops with the villagers to customise system siting, orientation, and ancillary uses (e.g., planting shade-tolerant crops under solar fields).
- Phased installation beginning with ground-mounted agrivoltaic systems and centralised BESS, followed by rooftop PV on key community structures.
- Reservoir rehabilitation and micro-hydro installation with community labour participation.
- Rainwater system commissioning, featuring locally built ferrocement storage tanks that are integrated into the landscape.

Throughout the pilot phase, we will adopt a co-design model, ensuring that community feedback refines the final construction details.

Knowledge transfer and training are embedded into every phase:

- Village Energy Committees (VECs) formed to lead oversight.
- Youth energy champions selected to shadow the installation teams.
- Workshops for operation, maintenance, safety, and minor troubleshooting.

In this way, the implementation is not only a technical success but also a social and cultural transformation, ensuring that the system is well understood, loved, and sustained long after the competition concludes.

4. Operations and Maintenance Statement

The operation and maintenance (O&M) strategy for *Vaka ni Lomani* is designed to empower Marou Village with the skills, structures, and knowledge necessary to sustain the energy and water systems independently for generations to come.

Operations

Daily system operations are simple, low-intervention, and community-driven:

- **Solar and BESS System**: Automated charge controllers, inverters, and smart metering will handle most energy flows. Visual dashboards located at the community centre will allow real-time monitoring of battery health, solar generation, and household usage trends.
- **Small Hydro System**: Trained village volunteers will conduct a weekly routine visual inspection of the water intake screens, pipelines, and turbine performance.
- **Water Systems**: Rainwater tanks will have simple overflow alarms and maintenance schedules for first-flush diverters and filters to ensure a clean water supply.

In partnership with project collaborators, such as the Fiji Rural Electrification Fund and the University of Fiji, the system will be integrated into national O&M support programs where available. However, its primary goal is to promote local autonomy.

Maintenance

Maintenance responsibilities will be structured around three tiers:

1. **Routine Maintenance (Monthly)**
    - Cleaning of solar panels (using rainwater when available).
    - Visual inspections for corrosion, loose wiring, or shading issues.
    - Check battery health through the user-friendly interface.
    - Water filter cleaning and checking of tank levels.

2. **Preventative Maintenance (Quarterly to Biannual)**
    - Electrical checks on connections and grounding by a certified technician (trained in village-based or island-based settings, where possible). Flow rate and pressure checks on the hydro system.
    - Detailed review of water pump performance and potential sediment removal in reservoirs.

3. **Major Maintenance (As Needed / 5–10 Year Intervals)**
    - Battery replacement or rebalancing (after ~10–12 years).
    - Solar inverter replacement (~10 years expected lifespan).
    - Hydro turbine and pump system refurbishment if wear is detected.

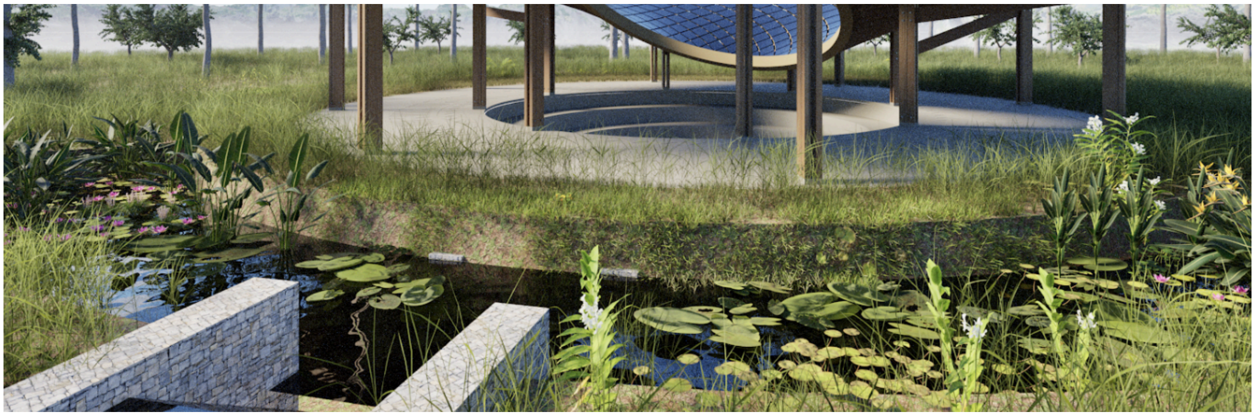
A **Village Energy and Water Committee (VEWC)**, composed of representatives from youth, elders, and women's groups, will oversee O&M. The committee will coordinate:

- Scheduling of routine tasks.
- Reporting faults and requesting external technical support if needed.
- Managing a small operations fund collected through modest energy tariffs or community fundraising to cover consumables, replacement parts, and professional services when required.

Capacity-building workshops will be refreshed every two years to ensure the next generation has the knowledge and pride to maintain the systems over their whole design life of 25–30 years.

By embedding operation and maintenance into the social fabric of Marou Village, *Vaka ni Lomani* becomes more than infrastructure — it becomes a living tradition of self-reliance, stewardship, and resilience.

5. Environmental Impact Assessment



The *Vaka ni Lomani* design has been carefully developed to minimise adverse environmental impacts while actively enhancing the local ecosystem and strengthening Marou Village's resilience to climate change.

Anticipated Environmental Impacts

Positive Impacts:

- Renewable Energy Transition: Displacing the use of imported diesel for electricity generation will reduce greenhouse gas emissions, air pollution, and fuel-related environmental risks.
- Water Security: Rainwater harvesting and managed reservoirs will help buffer the village against drought and freshwater scarcity, while reducing pressure on vulnerable underground aquifers.
- Flood Mitigation: Restoring and using Reservoir 1 and Reservoir 2 for stormwater management will help reduce land erosion and protect homes from flood damage during the rainy season.
- Biodiversity Support: Native biofiltration species in the Channel Reservoir provide habitat for local fauna.

Potential Negative Impacts:

- Construction Disturbance: Temporary disruption of soil, vegetation, and minor runoff risks during construction phases.
- Visual Impacts: Although minimal, solar panels and water infrastructure may alter the visual character of open land areas.
- Material Transport: Shipping materials to Naviti Island and transporting them to the site involves temporary carbon emissions and minor marine disturbance.

Mitigation Strategies

During Construction:

- Apply low-impact construction techniques, including manual assembly and hand tools, wherever possible, to minimise soil compaction and ecosystem disruption.
- Limit land clearance to the minimum necessary footprint, preserving existing vegetation as natural buffers around structures.
- Utilise local labour and materials where feasible to reduce shipping requirements and associated emissions.
- Use silt fences and erosion control barriers during earthwork projects near water bodies.

Design and Materials:

- Use cyclone-rated, corrosion-resistant structures built to last for at least 25 years, minimising the need for frequent material replacement.
  Favour local, natural, and biodegradable materials (e.g., timber, bamboo, woven coconut or pandanus for shade structures) in non-electrical components.
- Select energy and water technologies with recyclable components that have end-of-life pathways available.

Operation and Long-Term Stewardship:

- Establish a community-led monitoring program to track environmental impacts, particularly during the rainy season (erosion and flooding) and the dry season (water scarcity).

- Incorporate adaptive management, allowing the Village Energy and Water Committee to modify water flow, reservoir use, and farming practices as climate and community needs evolve.
- Plan for responsible decommissioning and recycling at the end of system life, guided by a decommissioning plan developed collaboratively with the community and national authorities.

Through these strategies, *Vaka ni Lomani* embodies principles of climate adaptation that not only avoids harm but actively nurtures the land, water, and people it serves, turning Marou Village into a beacon of regenerative design for the Pacific and the world.