# 1. Concept narrative

In this project, we define sustainability not just by how long a structure can stand, but by how little harm it leaves behind. A truly sustainable system is one that works in harmony with its environment: respecting the land, helping people, and changing over time.

Our proposal introduces a modular, raised infrastructure system that addresses core human needs: food, water, energy, and community, while leaving the natural ground untouched. The structure is lifted above the ground, creating minimal disruption to topography, soil life, or water flow. This makes it usable in diverse landscapes, without digging or grading.

The modular layout is based on a repeating structural grid, with some parts intentionally left open to fit any irregular or unpredictable site, and they become spaces of opportunity. Into these open grids, we strategically place solar towers, which address the community’s two greatest infrastructural challenges: off-grid electricity generation and rainwater collection. The solar structures are covered by woven bamboo, echoing local craft and softening their presence in the landscape so they appear not as foreign additions but as familiar, respectful forms.

The remaining grids hold our elevated agricultural planter boxes, designed as integrated food systems for community use. Each unit contains a biodegradable molded coconut coir liner, nested within a bamboo frame, supported by geotextile and drainage layers. These coir boxes can be replaced seasonally without disrupting the structure or the land, allowing for efficient crop rotation and a zero-waste growing cycle. Community members can use them to grow daily food or other crops for export, supporting both nutrition and household income.

What matters the most is that, this is not just a structure built for the community; it is a system built with the community. From fabrication to farming, local residents are engaged in every step: constructing bamboo frames, pressing coir liners, planting and harvesting, maintaining water systems. This is a community garden and public platform where residents of all ages are encouraged to contribute, cultivate, and care for their shared environment.

All materials are locally sourced and return harmlessly to the earth. These choices reduce embodied carbon, lower costs, and make the system replicable. It is modular, respectful to the environment, and brings a sense of belonging and presence to the community.

Ultimately, our design proposes that sustainability is not a static achievement; it is a living relationship between people and place. We offer a system that can be set up anywhere without harming the land, and in return, it provides food, clean water, and renewable energy. After decades of use, what remains is community, soil, and memories.

# 2. Technical Narrative

Our design relies on solar power to meet the electricity demand of Marou residents. The design was guided by the following limitations:

* Category 5 cyclone winds
* A Cost Constraint of $15 per Watt
* Compliance withIEC 61730-1**,** IEC 61730-2**,** orUL 1703
* Transportability
* Installation by non-experts

Based on the location of the development, the weather data from the closest weather station was used for most of our calculation (FJI WE Viwa, approx. 38 km from the site). The weather station distance from site is illustrated in Figure 1. Table 1 outlines details of the simulation weather file. The Typical Meteorological Year (TMY) weather file represents a year without unusual extremes in temperature or typical average conditions, suitable for energy simulation modelling.

Table 1. Simulation weather file details.

|  |  |
| --- | --- |
| **Weather File Property** | Value |
| **Location** | FJI WE Viwa |
| **Weather File Type** | The Typical Meteorological Year (TMY) |

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Figure 1. Weather Station distance from site

We compared different types of solar PV systems and ultimately narrowed down the choice to two options: Copper Indium Gallium Selenide (CIGS) or monocrystalline systems. The comparison is shown in Table 2:

Table 2. Comparative overview of two option

|  |  |  |
| --- | --- | --- |
| Parameter | Monocrystalline Silicon | CIGS Thin-Film |
| Efficiency | 18–23% | 16–20% |
| Weight (kg per panel) | 15–22 | 2–7 kg per panel |
| Form | Rigid, heavy glass | Flexible, lightweight |
| Cyclone Resistance | High (with reinforced mounting) | Excellent (low wind profile) |
| Space Efficiency | High | Moderate |
| Cost per Watt | $0.20 – $0.30 | $0.30 – $0.50 |
| Meet the standard | IEC 61730-1 / 61730-2, UL 1703 | IEC 61730-1 / 61730-2, UL 1703 |

The use of monocrystalline panels provides a more effective and economical solution for our system. But the most important issue is protecting the panels from cyclone winds. To reduce this, we designed a protective structure that places the panels 30 cm below the top edge.

Each of our structures generates 1.53 using 19 customized hexagonal monocrystalline panels. These types of panels are designed according to the required dimensions. It is important to make sure that the manufacturing process meets the standards shown in the Table 3. Our panel design is adaptive and compatible with other forms of monocrystalline panels.

Table 3. Required standard

|  |  |
| --- | --- |
| Category | Required Standard |
| Panel safety & performance | IEC 61730-1 and IEC 61730-2 or UL 1703 |
| Durability testing | IEC 61215 |
| Wind zone compliance | Structural mounting per AS/NZS 1170.2 or equivalent |
| Salt/marine exposure | IEC 61701 (salt mist) – desirable in coastal zones |
| Ammonia resistance | IEC 62716 – desirable in agricultural environments |

## 2.1 Battery

According to the Marou Energy Demand and Generation document, and according to COMET workshop simulation, the daily energy consumption is approximately 244 kWh.

Based on Viwa TMYx weather data analysis and regional experience:

* The maximum cloudy-day streak is estimated at 3–4 days.
* We designed for 3 full days of autonomy

We assumed a 90% depth of discharge (DoD) and a round-trip system efficiency of 95%. Fromthese parameters, we calculated that the required battery capacity is approximately 860 kWh.

We suggest two options for batteries:

1. EnerVenue ESV-4 (Nickel-Hydrogen)

2. Sungrow ST455kWh-110kW-4h

Table 4 compares these two models.

Table 4. Comparison of Battery Storage Options

|  |  |  |
| --- | --- | --- |
| Parameter | EnerVenue ESV-4 (Nickel-Hydrogen) | Sungrow ST455kWh-110kW-4h (LFP) |
| Chemistry | Nickel-Hydrogen (Ni-H₂) | Lithium Iron Phosphate (LFP) |
| Cycle Life | 30,000 + cycles (30+ years) | 6,000–8,000 cycles (15–20 years) |
| Number of Units Needed | 260 vessels (3 containers) | 2 containerized units (455 kWh each) |
| System Size (Area Needed) | 100–120 m² | 6–7 m² per unit (14 m² total) |
| Cooling Required | - | Liquid cooling built-in |
| Efficiency (Round Trip) | 86–90% | 90–92% |
| Temperature Range | -40°C to +60°C (no cooling) | 0°C to +55°C (needs cooling) |
| Flood/Cyclone Resilience | Extreme (originally aerospace design) | Good if positioned above the ground. |
| Maintenance | Very low (10+ years unattended) | Medium (yearly service for liquid system) |
| Installation Complexity | Medium to High (rack & wire 260 units) | Very easy (2 ready-to-go cabinets) |
| Shipping Time to Fiji | 6–9 months (direct import, USA origin) | 1–2 months (available from Australia) |
| Certification | UL 1973, UL 9540A | UL 1973, IEC 62619 |

Our first choice is the EnerVenue ESV-4 system; however, if site space is limited, ordering this battery is not possible or earlier delivery is required, then the Sungrow ST455 kWh-110 kW-4h configuration may be used instead.

# 3. Prototyping and Pilot Implementation Statement

## 3.1 Solar Panel Structure

This structure belongs to the people of Fiji and will be built with their hands and knowledge. The design begins with traditional foundations like Yavu, using local materials, familiar tools, and shared knowledge. The bamboo enclosure adds protection and brings a sense of cultural connection. Material palette for solar panel structure is shown in Table 5.

Table 5. solar panel structure Material Palette

| **Material** | **Use** |
| --- | --- |
| Dendrocalamus asper Bamboo | Posts |
| Guadua angustifolia Bamboo | woven enclosure |
| River stones | Dry-stacked base |
| Red clay and sand | Yavu filler |
| Galvanized Steel | Central support for solar panels and frames– rust-protected and anchored |
| Natural rope/lashing | Joint binding |

**Assembly**  
1. Ground cleared of grass, rocks, and waste; surface leveled.  
2. River stones stacked in neat layers to form the Yavu base.  
3. Red clay and sand added to fill gaps and compacted for strength.  
4. Large stones placed around the edges as a retaining wall.  
5. Galvanized Steel post installed at center to act as the main vertical support.  
6. Galvanized steel frame mounted onto the post, followed by installation of 19 hexagonal solar panels.  
7. Bamboo posts added around the structure.  
8. Inner bamboo enclosure tied in place with natural lashings.

**Features**  
• Built using local skills and natural materials.  
• Modular design allows for easy repairs or changes.  
• Withstands heavy rain, wind, and seasonal flooding.  
• Culturally familiar design invites local care.

**Maintenance & Operation**  
• Loose lashings and bamboo parts can be replaced with simple tools.  
• Steel post should be checked yearly for tilt or rust.  
• Bamboo enclosure may be re-tied or renewed as needed.  
• Designed so the community can look after it easily and together.

## 3.2 Planting module

The planter box is made of two main parts: an outer frame for strength and shape, and an inner liner for holding the soil. Material palette for Planting module is shown in Table 6.

Table 6. Planting module Material Palette

| **Material** | **Use** |
| --- | --- |
| Bamboo Dendrocalamus asper | Posts |
| Guadua angustifolia Bamboo | woven enclosure |
| Melina wood | Frame |
| Coir liner | Molded pot |
| Geotextile | Erosion-resistant liner |
| Volcanic gravel | Drainage layer |
| **River stones** | Dry-stacked foundation |
| **Red clay and sand** | Filler for Yavu |

**Assembly**

1. Yavu stone foundation built and leveled.
2. Bamboo posts installed with lashings and diagonal bracing.
3. Platform and top ring formed with Melina wood.
4. Bamboo slats installed as side enclosure.
5. Geotextile (natural mesh or fabric) fixed to internal walls.

**Outer box**

* Woven bamboo paneling (fishmouth weave).
* Geotextile inner lining (breathable, soil-retaining).
* Rim made of Melina wood frame for planter edge rigidity.

**Inner module**

* The molded coconut coir liner is pressed into shape using coconut fiber and natural binders.
* Coir liner sits inside geotextile-lined bamboo frame.
* Coir is reinforced with a bio-resin to prevent edge deformation.
* Gravel layer added to bottom for drainage, (can be washed and reused in place).

**Features**

* Rigid, breathable container for planting medium.
* Biodegradable and fully replaceable after 1-2 growing cycles.
* Roots can grow through as needed; promotes natural transplanting.

**Maintenance & Operation**

* Coir liners are easily replaced seasonally (allowing for clean crop rotation without disturbing the frame).
* Gravel layer can be rinsed and reused in place.
* Liners compost naturally after removal.
* Minimal tools required for ongoing care.

# 3.3 Cost Estimate

Figures are based on unit quantities, market prices, and average labor/material values. All costs are in USD and may be refined with supplier quotes and site logistics.

**Full implementation estimated cost:** **$872,403**  
Supports planning; adjustable per design, sourcing, and transport.

Locally sourced materials are excluded from direct costs. Only tools, solar components, and minor accessories are included.

**Revised estimate for 105 units:** **$778,203**  
Assumes extensive use of local resources—wood, bamboo, soil, coir, lashings—with purchased items limited to solar tech, battery storage, and steel/aluminum structures.

Community input lowers labor costs; basic stipends (~**$18,900**) account for setup, filling, bamboo work, and training.

Table 7.Estimated Component Costs

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Unit Cost (USD) | Qty (per unit × 105) | Estimated Total Cost |
| Solar Panels (150W Hexagon) | $160 | 19 × 105 = 1,995 | $319,200 |
| Battery (EnerVenue ESV-4) | - | - | $450,000 |
| Galvanized Steel Support Pipes (60mm, 4mm wall) | $75 | 4 × 105 = 420 | $7,875 |
| Galvanized steel for PV Panels | $35 | 19 × 105 = 1,995 | $69,825 |
| Controller + Cabling (electrical only) | $60 | 105 | $6,300 |
| Contingency (5%) | — | — | $19,203 |
| Total |  |  | **$872,403** |

# 3.4 Construction Timeline

With ~67 village households, ~60% participation is expected (~40 households). If each contributes one adult, a rotating crew of 12–20 people/day is feasible. With 4–5 hours of work/day/person, total daily labor averages 60–100 person-hours.

This shared labor model supports flexible participation via solesolevaki, with little reliance on outside contractors. Even with rest days and variable attendance, the full project can be completed in **~4 months**, across overlapping phases. The construction time line is shown in table 8.

### **Total Labor Need:** ~**10,500** person-hours

Table 8.Construction timeline

| **Phase** | **Labor Required** | **Time Estimate** | **Description** |
| --- | --- | --- | --- |
| **Site Prep & Foundation** | ~4,500 person-hours | ~56 days | Manual clearing, leveling, and traditional yavu building using red clay, sand, and dry stone. Labor-intensive and essential for stability. |
| **Planters, Bamboo, Solar** | ~6,000 person-hours | ~75 days | Simultaneous tasks: planter construction (coir, gravel, soil), bamboo weaving, and solar mounting. Skill needs vary—from farming to basic solar work. |

# 4. Operation and Maintenance Statement

**4.1 LCA analysis**

**Material Sourcing**  
The system uses a material palette optimized for sustainability and contextual fit. Melina wood, a fast-growing hardwood with a high strength-to-weight ratio, is used as the structural frame for planters. Grown in Fijian plantations, it aids carbon sequestration and reduces import emissions. “Dendrocalamus asper” and “Guadua angustifolia “ bamboo are selected for their high tensile strength and the ability to be locally propagated through rooted cuttings and enriched volcanic soils. Coconut coir, with ~45% lignin, serves as a planting liner for its biodegradability, ~60% moisture retention, and fungal resistance. A polypropylene-based geotextile forms the inner barrier to control soil migration and improve subgrade stability. Volcanic gravel and alluvial river stones support drainage and foundation layers, minimizing erosion and compaction. Red clay mixed with sand creates a thermally massive yavu base that reduces vibration and improves ground anchorage. Steel posts and PV frames are made of hot-dip galvanized steel for corrosion resistance, coastal durability, and full recyclability. Natural lashings and cane ties ensure flexible, repairable joints without synthetic fasteners.

**Construction**   
Assembly is modular, labor-intensive, and low-energy. No concrete or cementitious materials are used, avoiding CO₂ emissions. Melina and bamboo are pre-cut offsite and assembled with rope lashings for full disassembly. Excavation is manual, and the foundation system uses dry stone and compacted earth to support planters and solar modules. Steel PV supports are bolted and anchored without welding, allowing safe assembly in low-resource settings. This approach supports local jobs, traditional skills, and climate-resilient, flexible layouts.

**Operation**   
The system offsets carbon emissions via solar PV. Each 300W panel avoids ~150 kg CO₂ per year, assuming 4.5 peak sun hours daily in Fiji. Modular planters produce food with low water use; raised beds improve drainage and prevent saline intrusion—key for coastal resilience. Bamboo walls offer passive ventilation. No fossil fuels are used in operation.

**End-of-Life**   
Over 85% of materials are biodegradable or recyclable. Bamboo and Melina wood can be reused or composted. Coir liners degrade naturally in 2–3 years and are easily replaced. Galvanized steel frames are fully recyclable or reusable. Solar panels should be recovered and reintegrated via circular supply chains or EPR programs. Woven bamboo and ropes can be retied or converted to biomass. All parts are dry-connected for quick disassembly and redistribution after cyclones or for scaling.

# 5. Environmental Impact Assessment

**Key Risks Identified**

* **Environmental:** Cyclones, heavy rain, coastal erosion, saline intrusion.
* **Technical:** Potential damage to PV panels, degradation of bamboo/coir, inadequate drainage.
* **Social/Operational:** Irregular participation, weak maintenance follow-up, risk of misuse or theft of shared infrastructure.

**Resilience Strategies**

1. **Design-Based Measures:**Elevated yavu-style foundations mitigate flood risk. Bamboo and melina wood structures are wind-responsive and flexible. Modular, dry-assembled components enable easy disassembly, repair, or replacement without special tools.
2. **Community-Based Measures:**Construction follows solesolevaki, traditional cooperative labor, creating labor redundancy and shared ownership. Local training builds recovery capacity, and monitoring supports long-term stewardship.
3. **Maintenance and Recovery:**Maintenance uses local materials (bamboo, coir, lashings). Seasonal replacement is built into planter liners and woven panels. Solar systems are raised on galvanized steel and feature accessible wiring for easy inspection and repair.