

TECHNICAL SPECIFICATION

GSO Shade House Production System

Protected Vegetable Cultivation for the Phnom Samkos Wildlife Sanctuary

Prepared for

GLOBAL STUDENT OUTREACH

Food Security • Sustainable Livelihoods • Forest & Wildlife Protection • Climate Resilience — Rural Cambodia

Document Rev. 1.0 — April 20, 2020

Target Cost per Shade House Unit: USD \$2,000–\$2,500

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1. Executive Summary

This specification defines a **20 m × 6 m shade house production system** for Global Student Outreach (GSO) community sites in and around the **Phnom Samkos Wildlife Sanctuary** in the Cardamom Mountains of western Cambodia. The design addresses the sanctuary's extreme tropical rainfall (3,000–4,000 mm/year), intense heat and humidity, and limited open-field vegetable production potential by creating a protected, ventilated growing environment that extends the growing season, reduces pest pressure, and improves yield consistency for subsistence and market crops.

The shade house features a **cement base (0.3–0.5 m height)**, **wood or metal scaffolding frame**, **shade net wrap**, **hinged access door**, and a **vented roof design** that sheds monsoon rain while maximizing airflow. The system is paired with an **integrated natural pest control strategy** using chickens and ducks, and a **hand watering can or simple sprinkler irrigation system** suited to off-grid, low-pressure water sources.

The document covers structural design, crop selection for shade-house conditions (okra, spey, Malabar spinach, and complementary species), pest management, irrigation, and a complete bill of materials across the \$2,000–\$2,500 budget range.

2. System Overview — Key Design Parameters

Parameter	Specification	Notes
Footprint	20 m (length) × 6 m (width) = 120 m ² growing area	Single-bay design; expandable by adding bays
Base height	0.3–0.5 m cement or compacted-stone perimeter wall	Prevents monsoon flooding; excludes burrowing pests; drainage channel
Frame height (eave)	2.5–3.0 m	Allows standing access; tall crops (okra, trellised vines)
Ridge height	3.5–4.0 m	Vented roof peak for hot-air escape

Frame material	Treated hardwood (eucalyptus/ironwood) or galvanized steel tubing	Hardwood: lower cost, local; Steel: longer lifespan, termite-proof
Roof covering	50% shade cloth (aluminet or black) + vented ridge gap	Reduces heat stress; vented ridge prevents condensation
Wall covering	50% shade cloth on all sides; roll-up to 1.0 m for ventilation	Roll-up sides for monsoon airflow; drop sides for dry-season wind/dust
Door	1.0 m × 2.0 m hinged frame with shade cloth flap	Human access; wheelbarrow access if widened to 1.2 m
Floor	Native soil, improved with compost; raised beds optional	No concrete floor — root penetration essential
Irrigation	Hand watering can (primary) or low-pressure sprinkler (upgrade)	Matches off-grid, low-pressure spring/stream water sources
Budget	\$2,000–\$2,500 per unit	Materials, shade net, hardware, and community labor

3. Structural Design

3.1 Cement Base / Perimeter Wall

The shade house sits on a **raised perimeter foundation** that serves four functions: flood protection during the 6-month monsoon, a barrier to burrowing pests (rats, crabs), a drainage channel for shed roof water, and an anchor for the frame posts.

Component	Specification	Cost (USD)
Perimeter wall	20 m × 6 m rectangle; 0.3–0.5 m height; 150 mm thick; reinforced with bamboo or rebar	\$180–\$280
Footing depth	300 mm below grade on compacted gravel bed	Built into wall cost
Drainage channel	100 mm wide × 80 mm deep concrete gutter on exterior, sloped to corner outlet	\$30–\$50
Corner outlet	110 mm PVC drainpipe to soakaway or aquaponics tank	\$10–\$15
Interior floor	Native soil, tilled, with 100 mm compost layer; no concrete	\$20–\$40 (compost)

Construction notes:

Wall is ****not a full slab**** — the interior remains open soil for planting. This reduces cost by 60% versus a full concrete pad and allows root crops to penetrate native subsoil.

The 0.3–0.5 m height is sufficient to exclude rats, crabs, and surface floodwater in all but extreme events.

In high-water-table areas, increase height to 0.5 m and add a 200 mm gravel drainage layer beneath the wall footing.

3.2 Frame — Wood vs. Metal

Two frame options are provided. The **wood frame** is lower cost and uses locally available materials. The **metal frame** is higher initial cost but termite-proof and longer-lasting.

Option A: Treated Hardwood Frame (Lower Cost)

Component	Specification	Qty	Unit Cost	Total
Corner posts	15 cm × 15 cm treated hardwood (eucalyptus/ironwood), 3.5 m length	4	\$18	\$72
Intermediate posts	10 cm × 10 cm treated hardwood, 3.5 m length	10	\$10	\$100
Ridge beam	10 cm × 15 cm treated hardwood, 20 m length (spliced)	2	\$25	\$50
Purlins	5 cm × 7 cm treated hardwood, 6.0 m length	14	\$6	\$84
Bracing	5 cm × 7 cm diagonal hardwood braces	8	\$4	\$32
Post anchors	U-bolt or rebar stirrup set in cement wall	14 sets	\$3	\$42
Hardware	Bolts, washers, nails, wire	1 set	\$40	\$40
Wood treatment	Used motor oil + diesel dip (traditional) or commercial wood preservative	1 set	\$30	\$30
Subtotal — Wood Frame				**\$450**

Pros: 50% lower cost than steel; all materials available within 20 km; community carpentry skills sufficient.

Cons: 5–7 year lifespan in high humidity; termite risk if treatment skipped; requires replacement of posts 3–4 and purlins 5–7.

Option B: Galvanized Steel Frame (Longer Lifespan)

Component	Specification	Qty	Unit Cost	Total
Corner posts	75 mm × 75 mm × 3 mm galvanized steel RHS, 3.5 m	4	\$35	\$140
Intermediate posts	50 mm × 50 mm × 2.5 mm galvanized steel RHS, 3.5 m	10	\$18	\$180
Ridge beam	75 mm × 50 mm × 3 mm galvanized steel RHS, 20 m (spliced)	2	\$40	\$80

Purlins	40 mm × 40 mm × 2 mm galvanized steel angle, 6.0 m	14	\$12	\$168
Bracing	40 mm × 40 mm × 2 mm steel angle, diagonal	8	\$8	\$64
Post base plates	150 mm × 150 mm × 6 mm steel plate, bolted to cement wall	14	\$5	\$70
Hardware	Galvanized bolts, nuts, washers, self-drilling screws	1 set	\$60	\$60
Welding / cutting	Local steelworker fee (if not pre-fabricated)	1	\$80	\$80
Subtotal — Steel Frame				**\$842**

Pros: 15+ year lifespan; termite-proof; withstands monsoon winds; no maintenance.

Cons: 85% higher cost than wood; requires steel cutting/welding skills or transport from Pursat; heavier — requires crane or 4-person lift for ridge beam.

GSO Recommendation: Use the **wood frame** for the first 1–2 pilot units to validate design and community build capacity. Transition to **steel frame** for scale-up units (Years 2–3) using lessons learned.

3.3 Shade Net Wrap

Component	Specification	Qty	Unit Cost	Total
Roof shade net	50% shade, UV-stabilized HDPE, 22 m × 8 m (overhang allowance)	1	\$120	\$120
Wall shade net	50% shade, UV-stabilized HDPE, 2× (22 m × 3 m) + 2× (7 m × 3 m)	1 set	\$90	\$90
Ridge vent gap	200 mm open gap along ridge, covered with insect mesh (1 mm) to exclude large pests while venting	20 m	\$2/m	\$40
Roll-up side mechanism	Bamboo pole + rope pulley system to raise/lower wall shade net 0–1.0 m	2 sides	\$15	\$30
Shade net fasteners	UV-stabilized cable ties, spring clips, bungee cords	1 set	\$25	\$25
Subtotal — Shade Net				**\$305**

Design notes:

****50% shade**** is the sweet spot for Phnom Samkos: reduces peak temperature by 4–6°C while maintaining sufficient light for flowering crops (okra, peppers).

****Ridge vent**** is critical. In a 20 m × 6 m × 3.5 m structure, stagnant hot air at the ridge can reach 45°C+ without ventilation. The 200 mm open gap creates a chimney effect, drawing cool air through roll-up sides and exhausting hot air at the peak.

****Insect mesh over ridge vent**** prevents entry of large pests (moths, beetles) while allowing airflow. Fine mesh (1 mm) is sufficient — smaller pests (whitefly, thrips) are managed biologically.

3.4 Door & Access

Component	Specification	Qty	Unit Cost	Total
Door frame	5 cm × 7 cm treated hardwood or 40 mm × 40 mm steel angle, 1.0 m × 2.0 m	1	\$20	\$20
Door shade net	50% shade cloth panel, 1.1 m × 2.1 m, sewn to frame	1	\$8	\$8
Hinges	Heavy-duty galvanized T-hinge, 150 mm	2	\$4	\$8
Latch	Sliding bolt latch, galvanized	1	\$3	\$3
Subtotal — Door				**\$39**

Access note: For wheelbarrow access (compost, harvest), widen door to 1.2 m and use a double-leaf design. Add \$15 for extra frame and hardware.

3.5 Vented Roof Design Detail

The roof is the most critical design element in a tropical shade house. The Phnom Samkos design uses a **sawtooth / gable hybrid**:

Ridge vent gap (200 mm, insect mesh)

▲

/ / 15° / \ 15°

/ ————/————\———— ← Purlin line at 3.0 m

/ / Post Post

1. 5 m 2.5 m

Feature	Rationale
Dual 15° pitch	Sheds monsoon rain efficiently; low pitch reduces wind uplift vs. steep roof
200 mm ridge vent	Continuous hot-air exhaust; prevents condensation and fungal disease
Insect mesh over vent	Excludes moths, butterflies, large beetles; biological control handles smaller pests
Overhang 0.5 m each end	Protects door and roll-up sides from direct rain splash

4. Crop Selection — Species That Thrive in Shade Houses

The 50% shade and protected environment of the shade house is ideal for crops that suffer in full tropical sun or are vulnerable to monsoon damage. The following species are selected for Phnom Samkos based on heat tolerance, shade adaptability, market demand, and nutritional value.

4.1 Primary Crops

Crop	Botanical Name	Shade Tolerance	Growing Period	Yield (per 120 m ²)	Notes
Okra	*Abelmoschus esculentus*	Partial (benefits from 30–50% shade in peak heat)	60–70 days to first harvest; 90–120 days total	80–120 kg	High-value market crop; thrives in heat; reduced pod toughness under shade
Spey (Jute Mallow / Jew's Mallow)	*Corchorus olitorius*	High (prefers 40–60% shade)	30–45 days	60–100 kg	Staple leafy green in Khmer cuisine; fast turnover; continuous harvest
Malabar Spinach	*Basella alba* / *B. rubra*	High (prefers 30–50% shade)	45–60 days to first harvest; 6+ months continuous	40–60 kg	Perennial vine in tropics; mucilaginous leaves; high in vitamins A and C; trellised on shade house frame

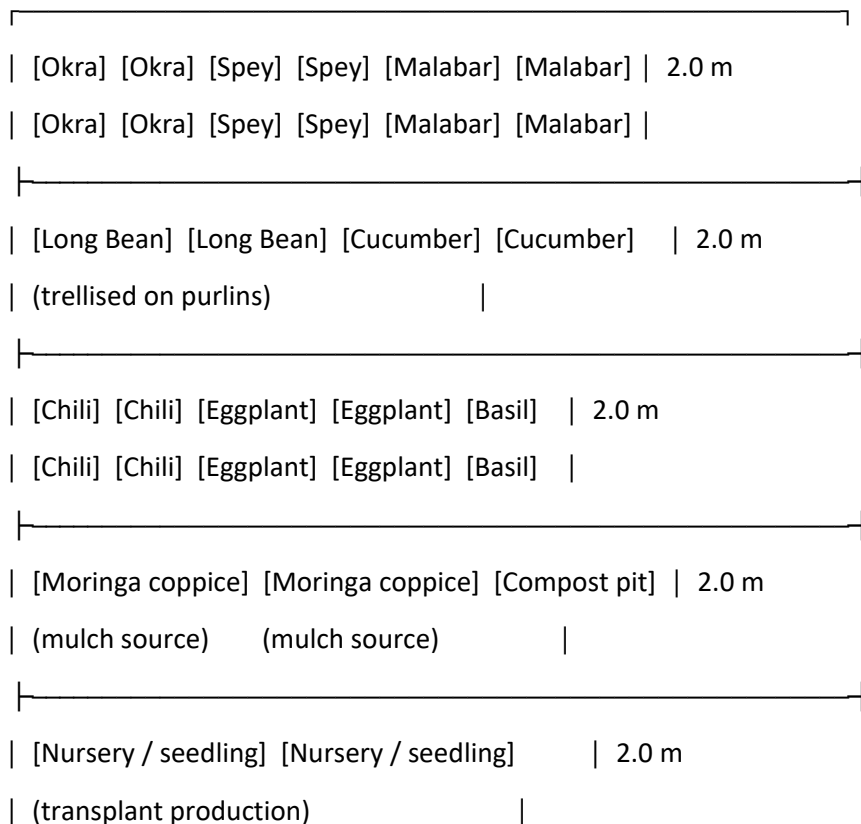
4.2 Secondary / Companion Crops

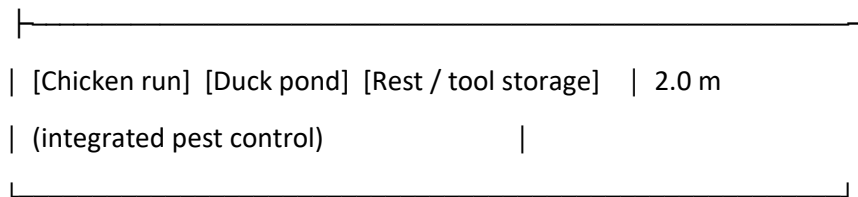
Crop	Botanical Name	Shade Tolerance	Role	Notes
Long Bean (Yardlong Bean)	*Vigna unguiculata* subsp. *sesquipedalis*	Moderate (30% shade acceptable)	Trellised vertical crop	Uses shade house frame as trellis; nitrogen-fixing; popular in Khmer cooking
Cucumber	*Cucumis sativus*	Moderate (benefits	Seasonal rotation	Fast growing;

		from afternoon shade)		market demand; needs vertical support
Thai Basil / Holy Basil	*Ocimum basilicum* / *O. tenuiflorum*	High	Herb / companion plant	Repels whitefly and aphids; high market value; continuous harvest
Chili Pepper	*Capsicum annuum* / *C. frutescens*	Moderate (40% shade reduces sunscald)	Spice / market crop	Shade reduces blossom drop in extreme heat; long harvest period
Eggplant (Thai Green)	*Solanum melongena*	Moderate	Fruit crop	Shade reduces fruit cracking; 4–6 month production cycle
Moringa	*Moringa oleifera*	High (young leaves)	Nutrient / mulch	Leaves for consumption and livestock feed; deep roots improve soil; coppiced at 1.5 m

4.3 Crop Rotation & Layout (120 m²)

20 m length





6 m width

Layout notes:

****Okra and spey**** are planted in 1.0 m wide raised beds, 0.3 m high, to improve drainage during monsoon.

****Malabar spinach**** is trellised on the shade house purlins and posts, using vertical space and shading the ground beneath.

****Long beans and cucumber**** are trellised on horizontal wires between purlins at 2.0 m height.

****Moringa**** is coppiced (cut to 1.5 m stump) every 3 months to provide leaf mulch and maintain manageable height.

****Nursery section**** produces seedlings for succession planting and for sale to neighboring families.

****Chicken / duck section**** is a 2 m × 6 m enclosed run at one end, with access to the shade house interior for supervised pest-foraging (see Section 6).

4.4 Seasonal Calendar

Month	Season	Primary Crops	Secondary Crops	Management Focus
Jan–Feb	Cool dry	Okra, spey, Malabar	Chili, eggplant	Irrigation peak; compost application; seedling production
Mar–Apr	Hot dry	Spey, Malabar, moringa	Basil, chili	Shade sides fully deployed; water 2× daily; pest scouting
May–Jun	Early monsoon	Spey, Malabar, long bean	Cucumber, eggplant	Roll-up sides for airflow; drainage check; first chicken release
Jul–Aug	Peak monsoon	Spey, Malabar, moringa	—	Minimal planting; focus on harvest; disease prevention; duck patrol
Sep–Oct	Late monsoon	Okra, spey, Malabar	Long bean, cucumber	Replanting after floods; compost turn; second chicken release
Nov–Dec	Post-monsoon	Okra, spey, chili	Eggplant, basil	Heavy composting; bed rebuilding; seed saving

5. Irrigation System

5.1 Water Source

Source	Suitability	Notes
Spring / stream	Excellent	Gravity-fed; no pump required if source is 5+ m above shade house
Rainwater collection	Excellent	Roof catchment from shade house overhang + adjacent structures; store in 1,000 L drum
Hand-dug well	Good	May require hand pump or small 12V solar pump
Village piped water	Good	If available; typically unreliable in Phnom Samkos
River (sanctuary)	Fair	Must be filtered; risk of contamination during floods

5.2 Hand Watering Can System (Primary — Low Cost)

Component	Specification	Qty	Unit Cost	Total
Watering can	10 L galvanized or plastic, rose head	4	\$8	\$32
Water storage	1,000 L plastic drum on 1.0 m stand (gravity fill)	1	\$45	\$45
Distribution	25 mm PVC line from source to drum, with tap	1 set	\$20	\$20
Subtotal — Hand Watering				**\$97**

Operation: Family member fills watering can from drum tap, walks beds, applies 2–3 L per m². For 120 m², this requires **30–40 minutes** and **240–360 L** per watering event. In dry season (Nov–Apr), water 1× daily. In monsoon, water only if 3+ days without rain.

Pros: Zero energy cost; precise water placement; low capital; no maintenance.

Cons: Labor-intensive; uneven coverage possible; difficult to scale beyond 120 m².

5.3 Simple Sprinkler System (Upgrade — Moderate Cost)

Component	Specification	Qty	Unit Cost	Total
Water storage	1,000 L drum on 2.0 m stand (gravity pressure)	1	\$55	\$55
Main line	25 mm PVC pressure pipe, 25 m	1	\$18	\$18
Lateral lines	20 mm PVC pressure pipe, 4×	4	\$10	\$40

	20 m			
Sprinkler heads	Low-pressure impact or micro-sprinkler, 2–4 m radius, 0.5–1.0 bar operating pressure	8	\$5	\$40
Risers	50 cm PVC riser, 20 mm, with thread	8	\$2	\$16
Valves / taps	25 mm ball valve at drum; 4× 20 mm line valves	1 set	\$15	\$15
Fittings	Elbows, tees, unions, end caps	1 set	\$20	\$20
Subtotal — Sprinkler				**\$204**

Operation: Drum filled by gravity from spring or by hand. Open valve, water flows through laterals, sprinklers cover 2–4 m radius each. For 120 m², **8 sprinklers** on 4 laterals provide full coverage. Run time: **20–30 minutes** to apply 20–25 mm equivalent. In dry season, run 2× weekly. In monsoon, run as needed.

Pros: 50% less labor than hand watering; even coverage; can run while family does other tasks; scalable to multiple shade houses from one drum.

Cons: Higher capital (\$204 vs. \$97); requires 2.0 m drum stand for pressure; sprinklers can clog with sediment; wind during dry season causes uneven distribution.

GSO Recommendation: Start with **hand watering cans** for the first growing season to learn water requirements and bed layout. Upgrade to **simple sprinkler** in Season 2 if labor is a constraint or if expanding to a second shade house.

6. Natural Pest Control — Integrated System

The Phnom Samkos shade house employs a **multi-layer natural pest control strategy** that minimizes or eliminates synthetic pesticide use. The approach combines physical barriers (shade house itself), biological control (beneficial insects attracted by companion plants), and animal control (chickens and ducks).

6.1 Physical Barriers

Barrier	Function	Implementation
Shade house structure	Excludes large pests (birds, monkeys, large insects)	Shade net walls and roof create a sealed environment
Ridge insect mesh	Excludes moths, butterflies, large beetles while venting	1 mm mesh over 200 mm ridge gap
Cement base wall	Excludes burrowing pests (rats, crabs, cutworms)	0.3–0.5 m height; smooth concrete surface
Raised beds (0.3 m)	Reduces soil-borne pest access; improves drainage	Compost-filled beds on native soil
Companion planting	Repels pests; attracts beneficials	Basil, marigold (if available), moringa interplanted

6.2 Biological Control — Beneficial Insects

Beneficial	Target Pest	Attraction Method
Ladybugs	Aphids, whitefly, mealybug	Plant dill, fennel, coriander near shade house
Lacewings	Aphids, thrips, caterpillars	Plant sunflowers (if space allows) or flowering mustard
Parasitic wasps	Caterpillars, aphids	Plant flowering buckwheat or alyssum
Predatory mites	Spider mites	Maintain humidity >60% (shade house naturally achieves this)
Ground beetles	Cutworms, slugs, snails	Mulched pathways and compost pits provide habitat

6.3 Chicken Integration — Insect & Weed Control

Chickens are the **primary mobile pest control unit** in the GSO shade house system. They are not housed inside the shade house permanently — they are brought in for **supervised foraging sessions**.

Parameter	Specification
Flock size	3–5 chickens per 120 m ² shade house
Breed	Indigenous Cambodian chicken or crossbred layer (low input, heat-tolerant)
Housing	Simple 1.5 m × 2.0 m bamboo coop adjacent to shade house; elevated 0.5 m; nest box
Feed	70% scavenged (insects, weeds, seeds); 30% rice bran / kitchen scraps supplement
Water	Shared duck pond or separate hanging bucket

Pest Control Protocol:

Timing	Activity	Duration	Target Pests
Pre-planting (2 weeks before sowing)	Confine chickens inside shade house on bare soil	30 min/day × 10 days	Cutworms, beetle larvae, weed seeds, slug eggs
Post-harvest (1 week after final crop removal)	Confine chickens inside shade house on stubble	30 min/day × 7 days	Residual pests, weed seeds, fallen fruit
Mid-season (supervised)	Release chickens for 20–30 min between rows	2× weekly	Aphids, caterpillars, Japanese beetles, grasshoppers
Permanent perimeter	Chicken coop placed 2 m from shade house door	Continuous	Attracts slugs and snails away from crops; chickens eat them

Critical rules:

****Never release chickens when crops are young seedlings**** (< 3 weeks old). Chickens will scratch up and eat small plants.

****Never release chickens near fruiting crops**** (okra pods, cucumber fruit). They will peck and damage harvest.

****Supervise all mid-season releases.**** One person watches the flock and redirects them from crops to pathways.

****Collect manure daily**** from the chicken coop and compost it. Do not apply fresh chicken manure directly to beds (too high in nitrogen, can burn plants).

Chicken coop cost: \$25–\$40 (bamboo, thatch, nest box, perch).

6.4 Duck Integration — Slug & Snail Control

Ducks are the **specialist slug and snail hunters** of the system. They are particularly valuable in Phnom Samkos, where the wet monsoon season creates ideal conditions for slug explosions.

Parameter	Specification
Flock size	2–3 ducks per 120 m ² shade house
Breed	Khaki Campbell or indigenous Cambodian duck (good foragers, heat-tolerant)
Housing	1.5 m × 2.0 m bamboo pen with 0.5 m × 1.0 m shallow pond (plastic-lined depression)
Feed	60% scavenged (slugs, snails, insects, aquatic plants); 40% rice bran / kitchen scraps
Water	Shallow pond (20 cm deep) refreshed every 2–3 days; shared with irrigation drum overflow

Pest Control Protocol:

Timing	Activity	Duration	Target Pests
Monsoon season (May–Oct)	Release ducks inside shade house for 1 hour at dawn	Daily	Slugs, snails, earthworms (non-pest, but ducks eat them)
Post-rain events	Release ducks immediately after heavy rain	30 min	Slugs and snails emerge from soil — peak hunting time
Dry season (Nov–Apr)	Reduce to 2× weekly; supplement with rice bran	30 min	Residual slugs in mulched areas
Permanent pond	Duck pond placed at low corner of shade house	Continuous	Attracts slugs from beds to moist area; ducks patrol perimeter

Critical rules:

****Ducks do not scratch like chickens.**** They can be released among established crops without uprooting plants.

****Ducks will eat small seedlings.**** Wait until plants are > 15 cm tall before allowing duck access.

****Ducks require water.**** The shallow pond must be cleaned every 2–3 days to prevent mosquito breeding. Water can be used for irrigation after cleaning.

****Duck manure is liquid and high in nitrogen.**** Collect pond sludge and compost it before applying to beds.

Duck pen + pond cost: \$35–\$55 (bamboo pen, plastic pond liner, small ramp).

6.5 Additional Natural Remedies

Pest	Natural Remedy	Application
Aphids	Neem oil spray (1% solution)	Spray undersides of leaves; repeat every 7 days
Whitefly	Insecticidal soap (potassium salt + water)	Spray in early morning; avoid beneficials
Caterpillars	Bt (* <i>Bacillus thuringiensis</i> *) spray	Targeted; safe for beneficials
Slugs / snails	Beer traps + duck patrol	Buried saucer of beer; empty daily
Spider mites	Strong water blast + increased humidity	Hose undersides of leaves; shade house humidity helps
Fungal disease (damping off, mildew)	Copper fungicide (Bordeaux mix) or baking soda spray	Apply at first sign; improve airflow
Nematodes	Marigold interplanting + compost tea	Plant marigold borders; apply compost tea monthly

6.6 Pest Control Calendar

Month	Primary Threat	Chicken Role	Duck Role	Spray / Other
Jan–Feb	Aphids on okra	Perimeter patrol	Pond maintenance	Neem oil if > 5 aphids/leaf
Mar–Apr	Whitefly, spider mites	Supervised release 2×/week	2×/week	Insecticidal soap; water blast
May–Jun	Slug explosion, cutworms	Pre-planting soil prep	Daily dawn release	Beer traps; Bt for caterpillars
Jul–Aug	Fungal disease (monsoon)	Minimal (wet feathers)	Daily (slugs peak)	Copper fungicide; remove infected leaves
Sep–Oct	Aphids, whitefly on new plantings	Post-harvest soil clean-up	3×/week	Neem oil; compost tea
Nov–Dec	Minimal pest pressure	Coop cleaning; manure collection	2×/week	Seed saving; bed prep

7. Soil & Fertility Management

7.1 Bed Preparation

Layer	Depth	Material
Subsoil	Native	Loosened with fork to 300 mm; no compaction
Drainage layer	100 mm	Coarse gravel or broken pottery at bed bottom (if heavy clay)
Compost layer	150–200 mm	Mature compost (chicken + duck manure + crop residues + rice straw)

Topsoil / mulch	50 mm	Fine compost or rice straw mulch
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7.2 Annual Fertility Inputs (per 120 m²)

Input	Quantity	Source	Cost (USD)
Compost	2,000–3,000 kg	On-farm (chicken/duck manure + crop residues)	\$0 (labor)
Rice ash	100 kg	Household cooking fires	\$0
Bone meal / fish meal	20 kg	Local market	\$8–\$12
Wood ash (potassium)	50 kg	Cooking fires	\$0
Liquid compost tea	200 L	On-farm fermentation	\$0
Total annual fertility cost			**\$8–\$12**

8. Bill of Materials & Cost Summary

8.1 Complete Shade House (\$2,000–\$2,500)

Category	Item	Qty	Unit Cost (USD)	Total (USD)
A. Cement Base	Perimeter wall (0.3–0.5 m × 150 mm), 52 m perimeter; cement, sand, gravel, bamboo rebar	1	\$220	**\$220**
	Drainage channel + corner outlet	1	\$45	**\$45**
	Interior soil prep + compost layer	1	\$30	**\$30**
B. Frame (Wood Option)	Hardwood posts, ridge beam, purlins, bracing, anchors, hardware, treatment	1 set	\$450	**\$450**
C. Shade Net & Covering	Roof shade net (50%, 22 m × 8 m)	1	\$120	**\$120**
	Wall shade net (50%, 2 × 22 m × 3 m + 2 × 7 m × 3 m)	1 set	\$90	**\$90**
	Ridge vent insect mesh (1 mm, 20 m)	20 m	\$2/m	**\$40**
	Roll-up side mechanism (bamboo + rope)	2	\$15	**\$30**
	Fasteners (cable ties, clips, bungee)	1 set	\$25	**\$25**
D. Door	Frame + shade net + hinges + latch	1	\$39	**\$39**
E. Irrigation	Hand watering system (drum,	1 set	\$97	**\$97**

	cans, PVC line)			
	OR: Simple sprinkler upgrade (drum, laterals, 8 sprinklers)	1 set	\$204	***\$204**
F. Pest Control Integration	Chicken coop (bamboo, 1.5 m × 2.0 m, elevated)	1	\$35	***\$35**
	3 chickens (indigenous)	3	\$5	***\$15**
	Duck pen + pond (bamboo + liner)	1	\$45	***\$45**
	2 ducks (Khaki Campbell or local)	2	\$6	***\$12**
G. Tools & Startup	Hoe, rake, watering can, hand trowel, seed packets, neem oil, Bt	1 set	\$60	***\$60**
H. Labor	Community crew (4 people, 5 days)	1	\$200	***\$200**
I. Contingency	10% buffer	—	—	***\$180**
			TOTAL (Hand Watering)	***\$2,025**
			TOTAL (Sprinkler Upgrade)	***\$2,132**

Target: USD \$2,000–\$2,500 per shade house unit.

8.2 Cost Reduction Strategies

Strategy	Saving
Use wood frame instead of steel	\$390 saved
Hand watering instead of sprinkler	\$107 saved
Source chickens and ducks from existing village stock	\$20–\$30 saved
Family labor instead of hired crew	\$150–\$200 saved
Use on-farm compost instead of purchased fertilizer	\$30–\$50 saved
Source shade net from Thai border market (bulk)	\$30–\$50 saved

9. Operations & Maintenance

9.1 Daily Schedule (Per Shade House)

Time	Task	Duration
06:00	Open roll-up sides; visual pest scan; water check	15 min
06:30	Hand water or run sprinkler (dry season)	30–40 min
07:00–10:00	Harvest mature crops; remove	1 hr

	diseased leaves; scout pests	
10:00–11:00	Release chickens or ducks for supervised foraging (if scheduled)	30 min
16:00	Hand water or run sprinkler (dry season second watering)	30 min
16:30	Close roll-up sides before evening rain/wind	10 min
17:00	Collect chicken/duck eggs; clean coop/pen; collect manure	20 min
Total daily labor		**2.5–3.5 hours**

9.2 Weekly Tasks

Task	Time
Weed pathways and bed edges	1 hr
Inspect shade net for tears; repair with cable ties	30 min
Turn compost pile; collect chicken/duck manure	30 min
FAMACHA-style pest count (record pest pressure per bed)	20 min

9.3 Monthly Tasks

Task	Time
Apply compost tea or side-dress compost	1 hr
Deep clean chicken coop and duck pond	1 hr
Record harvest weights; plan succession planting	30 min
Inspect cement wall and drainage for cracks	15 min

9.4 Seasonal Tasks

Season	Task
Pre-monsoon (Mar–Apr)	Secure shade net fasteners; clear drainage; reinforce door; stock neem oil
Post-monsoon (Oct–Nov)	Repair monsoon damage; replenish compost; replant beds; seed saving
Dry season (Dec–Feb)	Maximize roll-up side ventilation; deep water 2× daily; dust mulch

10. Expected Yields & Economics

10.1 Annual Production (120 m²)

Crop	Annual Yield	Market Value (USD)	Household Value (USD)
Okra	150–200 kg	\$150–\$250	\$75–\$125
Spey	200–300 kg	\$100–\$180	\$50–\$90
Malabar Spinach	100–150 kg	\$60–\$100	\$30–\$50
Long Bean	80–120 kg	\$80–\$120	\$40–\$60
Chili	30–50 kg	\$60–\$100	\$30–\$50

Eggplant	60–100 kg	\$60–\$100	\$30–\$50
Basil / herbs	10–20 kg	\$30–\$50	\$15–\$25
Total		**\$540–\$900**	**\$270–\$450**

10.2 Economics Summary

Metric	Value
Initial investment	\$2,000–\$2,500
Annual operating cost	\$100–\$150 (seeds, minimal feed, neem oil, tools)
Annual gross revenue (market sales)	\$540–\$900
Annual household consumption value	\$270–\$450
Net annual cash profit	\$390–\$750
Payback period	2.5–4 years
Return on investment	20–35% annually (cash) + 15–20% (household nutrition)

****Note:**** *Yields assume moderate management (daily watering, weekly pest scouting, monthly composting). High-management families can achieve 30–50% higher yields. Low-management families (irregular watering, no pest control) may see 50% lower yields.*

11. Safety & Conservation Alignment

****No chemical pesticides:**** The integrated pest control system (chickens, ducks, neem, Bt, companion planting) eliminates synthetic pesticide use, protecting sanctuary waterways and soil biology.

****Water conservation:**** Hand watering and low-pressure sprinklers minimize water use versus flood irrigation. Rainwater catchment from the shade house roof supplements supply.

****Soil building:**** Composting of chicken/duck manure and crop residues builds soil organic matter, reducing erosion risk on the sanctuary's steep slopes.

****Biodiversity support:**** Beneficial insect plantings (dill, coriander, flowering mustard) support pollinator and predator populations in the community zone.

****Community zone only:**** Shade house construction and cultivation are restricted to the sanctuary community zone. No forest clearance is required — the structure sits on existing fallow or degraded land.

****Seed saving:**** Families are trained to save seeds from open-pollinated varieties, reducing dependency on external inputs and preserving local crop diversity.

12. Revision & Contact

This is a planning-stage specification (Rev. 1.0) intended to guide pilot shade house construction across the first GSO community cohort in Phnom Samkos. Local material prices, shade net availability, and water source reliability should be validated on the ground in Pursat or Battambang province before scaling.

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