in association with Our Mother Earth Foundation

WORK PROGRAM

RECLAIMED FARMING FACILITIES

Modular 1-Hectare Controlled AWD Rice Cells and Fish Production Cells — Republic of Ghana

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Expanded from the client's engineering concept notes into a structured work program for planning, contractor scoping, and supervision. Follows on from reclamation of the underlying degraded site to productive agricultural use.

1. INTRODUCTION AND PURPOSE

This Work Program sets out the methodology, infrastructure design principles, resourcing, and schedule for establishing productive farming facilities — Alternate Wetting and Drying (AWD) rice production and pond-based fish production — on reclaimed land. It is the direct follow-up to the site restoration work (see companion Work Program: Land Restoration and Processing of Degraded Sites) and converts the client's engineering concept notes into a structured, phased program suitable for planning, contractor tendering, and supervision.

The system is built around a standardized 1-hectare production cell as the base module, for both rice and fish, so that infrastructure, procedures, and monitoring scale predictably from a pilot block up to a full commercial farm (1 ha cell -> 10 ha production block -> 100 ha sector -> centralized processing/utilities complex).

2. SCOPE OF WORKS

- Separation and preparation of reclaimed ponds/cells for rice and fish farming, and establishment of the farmer/technician teams that will tend each.
- Design and construction of a three-reservoir water system (raw water, irrigation, and return/recovery water) with fully separated supply and drainage networks.
- Construction of engineered, compacted perimeter levees and service roads around every production cell.
- Precision land grading of rice cells and controlled-grade shaping of fishpond bottoms toward a harvest sump.
- Independent inlet and outlet control structures for every 1-hectare cell (rice and fish), with flow metering.
- Soil permeability testing to determine where synthetic lining is required versus compacted clay/puddled retention.
- Nursery/tray systems for rice seedlings and a separate hatchery/fingerling/nursery/grading chain for fish.
- Aeration, feeding, monitoring, and telemetry infrastructure for the fish production blocks.
- Biosecurity sectoring of production blocks with independent isolation, and centralized shared infrastructure (nursery, feed storage, laboratory, water treatment, standby power, harvest/processing, cold storage).

Excluded from this scope (unless separately instructed): underlying site remediation/contamination clearance (covered under the Land Restoration Work Program), land tenure/water-rights negotiation, and ongoing farm operating management once the facility is commissioned and handed over.

3. APPLICABLE STANDARDS AND REFERENCE GUIDANCE

- FAO irrigation and pond-construction guidance — nursery sizing, distribution/control structures, geomembrane lining considerations, pond dike side slopes, and outlet drainage-time targets.
- IRRI Alternate Wetting and Drying (AWD) methodology — perforated field-water tube monitoring and re-irrigation triggers.

- CGIAR/CCAFS research on AWD water and methane-reduction outcomes, referenced for the farm's measurable low-methane production objective.
- Texas A&M/USDA pond-construction guidance — soil suitability (fine-textured clay/silty-clay) for water retention.
- Water Resources Commission (WRC) Ghana and EPA Ghana requirements for water abstraction, reservoir construction, and effluent/discharge management.

4. MODULAR SITE LAYOUT CONCEPT

The farm is organized as a repeating modular hierarchy rather than a single undifferentiated area of ponds/paddies:

- 1-hectare production cell (approx. 100 m x 100 m net planted/water area) the base unit for both rice and fish, each with its own inlet, outlet, and identification number.
- 10-hectare production block (10 x 1-ha cells) shares a metering station, control cabinet, and biosecurity/isolation boundary.
- 100-hectare sector (10 blocks) shares major supply/drainage infrastructure and can be isolated as a unit if required.
- Centralized utilities and processing complex serving multiple sectors: fingerling nursery, feed storage/silos, laboratory, water-treatment system, standby generation, harvest/processing facility, cold storage, and water-recovery system.

Note that the actual land footprint of each 1-ha cell will exceed one hectare once levees, roads, and canals are accounted for; this should be factored into land-area planning from the outset.

5. WATER INFRASTRUCTURE AND RESERVOIR SYSTEM

5.1 Three-Reservoir Concept

- Raw Water Reservoir — receives river, rainfall, borehole, or other primary water source.
- Irrigation Reservoir — supplies controlled water to the production cells.
- Return Water Reservoir — receives AWD/pond drainage and stormwater ahead of treatment and recycling.

5.2 Supply/Drainage Separation

Water must never run serially from cell to cell (Cell 1 -> Cell 2 -> Cell 3). Every cell receives water directly from a supply canal/header and discharges independently into a separate drainage/recovery canal. Clean supply infrastructure and effluent/recovery infrastructure should sit on physically separate sides of the production blocks.

5.3 Water Recovery Loop

Drainage from cells is directed to a collection canal, then a settling/solids-recovery basin, then (where necessary) treatment/monitoring, before returning to the irrigation reservoir for reuse. For the fish sectors, solids-laden effluent should pass through a dedicated settling basin and, where nutrient reuse is intended (irrigated crops, forage, wetlands, aquaponics), constructed-wetland or biological treatment before recycling.

6. LEVEE, BUND, AND ROAD CONSTRUCTION

- All perimeter levees are engineered, compacted earth — not simple agricultural berms — sized from site-specific soils, rainfall, flood risk, and equipment loads by the civil/geotechnical engineer.
- Primary dividing levees/roads (rice): conceptual 3-5 m crest width to carry farm vehicles and control structures; narrower secondary bunds where equipment access is not required.
- Perimeter levees (fishponds): conceptual 3-4 m usable crest width for feed trucks, maintenance and harvest vehicles, aerator service, and emergency response; conceptual dike side slope around 2H:1V (typical FAO range 1.5H:1V to 3H:1V), subject to site soils.
- Well-compacted bunds/levees are treated as fundamental to water control — seepage through poorly compacted banks defeats precise AWD management and pond water-quality control.

7. LAND AND POND-BOTTOM SHAPING

7.1 Rice Cells — Precision Level Grading

- GPS/laser land grading, final soil preparation, elevation verification, and a permanent benchmark for every cell.
- Target flatness: centimeter-level variation across each hectare, not tens of centimeters — an uneven cell makes AWD control (simultaneous dry/flooded zones) unreliable.

7.2 Fish Cells — Controlled Grade to Harvest Sump

- Unlike rice cells, pond bottoms carry a slight, controlled grade from the high end down to a deep harvest sump at the outlet end.
- This shapes complete drainage, concentrates sediment for manageable removal, and concentrates fish into the harvest zone at draw-down.
- Outlet structures should be sized so a pond can be fully drained in roughly one to two days, consistent with FAO guidance for larger ponds.

8. INLET, OUTLET, AND CONTROL STRUCTURES

8.1 Rice Cells (per hectare)

- Inlet: isolation gate, flow-control valve/sluice, flow meter, erosion protection, optional automated actuator, and cell identification number.
- Outlet/drain: independent gated outlet or standpipe at the hydraulic low point, connected to a dedicated drainage channel, enabling flood -> hold -> drain/decline -> dry -> measure -> re-irrigate operation.

8.2 Fish Cells (per hectare)

- Inlet: screen (excludes unwanted fish/predators/debris), isolation gate/valve, flow meter, inlet pipe/sluice.
- Outlet: independently controllable monk structure / standpipe / sluice / gated drain permitting graduated level control (hold -> lower 10 cm -> hold -> lower further -> drain -> harvest -> fully empty), with escape-prevention screening.
- Deep harvest sump at the outlet end, with road access positioned for a live-haul truck to load directly at the sump.

9. SOIL SEALING AND LINING STRATEGY

- Perform native-soil permeability testing before committing capital to synthetic lining on any cell or pond bottom.
- Where soils are sufficiently clayey/low-permeability, use an engineered compacted-clay or puddled layer for water retention in preference to exposed geomembrane beneath crops or fish.
- Where soils are sandy/highly permeable, bury and protect any geomembrane rather than exposing it directly under the production surface, with particular care in detailing around fish-pond harvest sumps and outlets where traffic and hydraulic forces concentrate.
- Prioritize lining of water-delivery and containment infrastructure — main and lateral irrigation canals, reservoirs, holding ponds, and drainage/recovery basins — as this typically offers a better return than lining every hectare of production surface.

10. SEED, NURSERY, AND STOCKING SYSTEMS

10.1 Rice — Seed to Transplant

1. Select and prepare certified seed suited to local climate, soil, disease pressure, and season; establish only the quantity needed for the planned acreage.
2. Raise seedlings in a controlled nursery (mat/tray nursery preferred over open beds for transplant uniformity), sized at roughly 5-10% of the final planted area.
3. Prepare paddies concurrently: maintain bunds, establish irrigation/drainage channels, till/puddle soil, and complete precision leveling per Section 7.1.
4. Transplant relatively young seedlings (commonly 20-30 days old) using a mechanical rice transplanter at commercial scale, at consistent spacing on the order of 20-30 cm rather than dense clumps.

10.2 Fish — Hatchery to Grow-Out

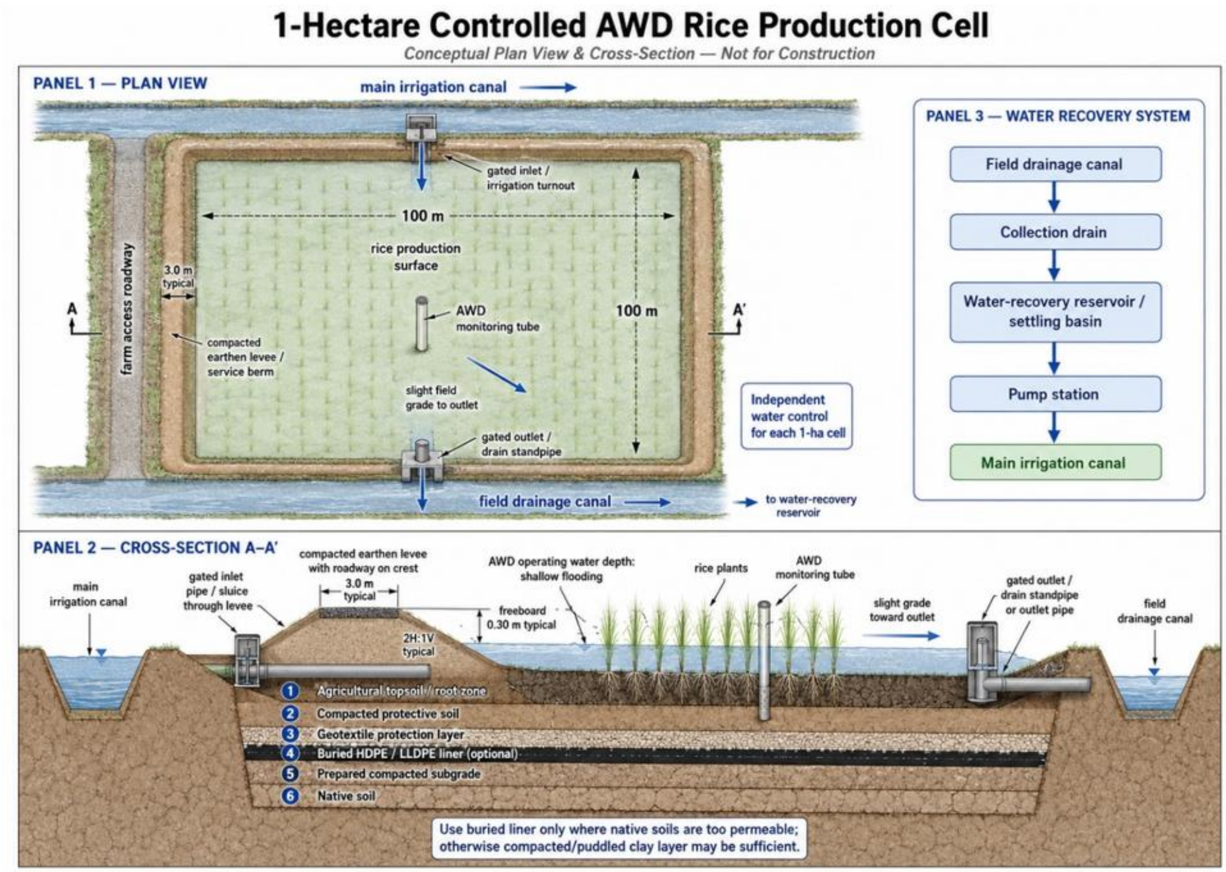
- Maintain a separate hatchery/fingerling receiving area, nursery, and grading area distinct from the 1-hectare grow-out ponds, so only uniformly sized fish are stocked into production cells.
- Operate stocking on a cohort basis (e.g., Ponds 1-2 stocked in one month, Ponds 3-4 the next) to give predictable, staggered harvest and cash flow, and to allow tilapia and catfish protocols to be kept separate where both are produced.

11. RICE CELL OPERATING CYCLE (AWD)

1. Keep water shallow (a few centimeters) during establishment rather than flooding deeply; excessive depth interferes with tillering.
2. After establishment, operate Alternate Wetting and Drying: irrigate, allow the water level to decline, and re-irrigate before the crop reaches damaging water stress, rather than maintaining continuous deep flooding.
3. Fit each cell with an AWD observation tube (perforated field-water tube); re-irrigation is commonly triggered around 15 cm below the soil surface during most of the crop cycle, with modified management during sensitive reproductive stages.
4. Where telemetry is included, pair the tube with an electronic water-level sensor and soil-moisture sensor so each cell reports surface/subsurface water level, soil moisture, and days since last irrigation.
5. Apply fertilizer in stages (establishment, active tillering, panicle initiation) rather than as a single application, guided by soil testing and local agronomic recommendations.

6. Stop irrigation and drain the cell ahead of harvest so equipment can operate efficiently and grain matures uniformly.

Design note: AWD drainage capacity and stormwater drainage capacity are related but distinct engineering problems — a single hectare receiving 75 mm of rain must shed roughly 750 m3 of water without overtopping the levees, so outlet/drainage sizing should be based on the site's extreme rainfall, catchment area, soil infiltration, and downstream conditions, not on AWD flows alone.



12. FISHPOND OPERATING SYSTEMS

12.1 Depth, Aeration, and Power

- Design around an average operating depth of approximately 1.2-1.5 m (roughly 12,000-15,000 m3, i.e., 12-15 million liters, per hectare), subject to species, stocking density, and climate.
- Install permanent aeration infrastructure from the outset (not as a retrofit); position aerators (e.g., paddlewheel) to establish a gentle circulating current that also pushes suspended solids toward the harvest end, rather than simply aerating at fixed points.
- Provide redundant power: grid/primary power plus a standby generator, with separate circuit protection per pond so one aerator failure does not shut down the whole pond; consider independent emergency aeration/oxygen capability for high-density production.

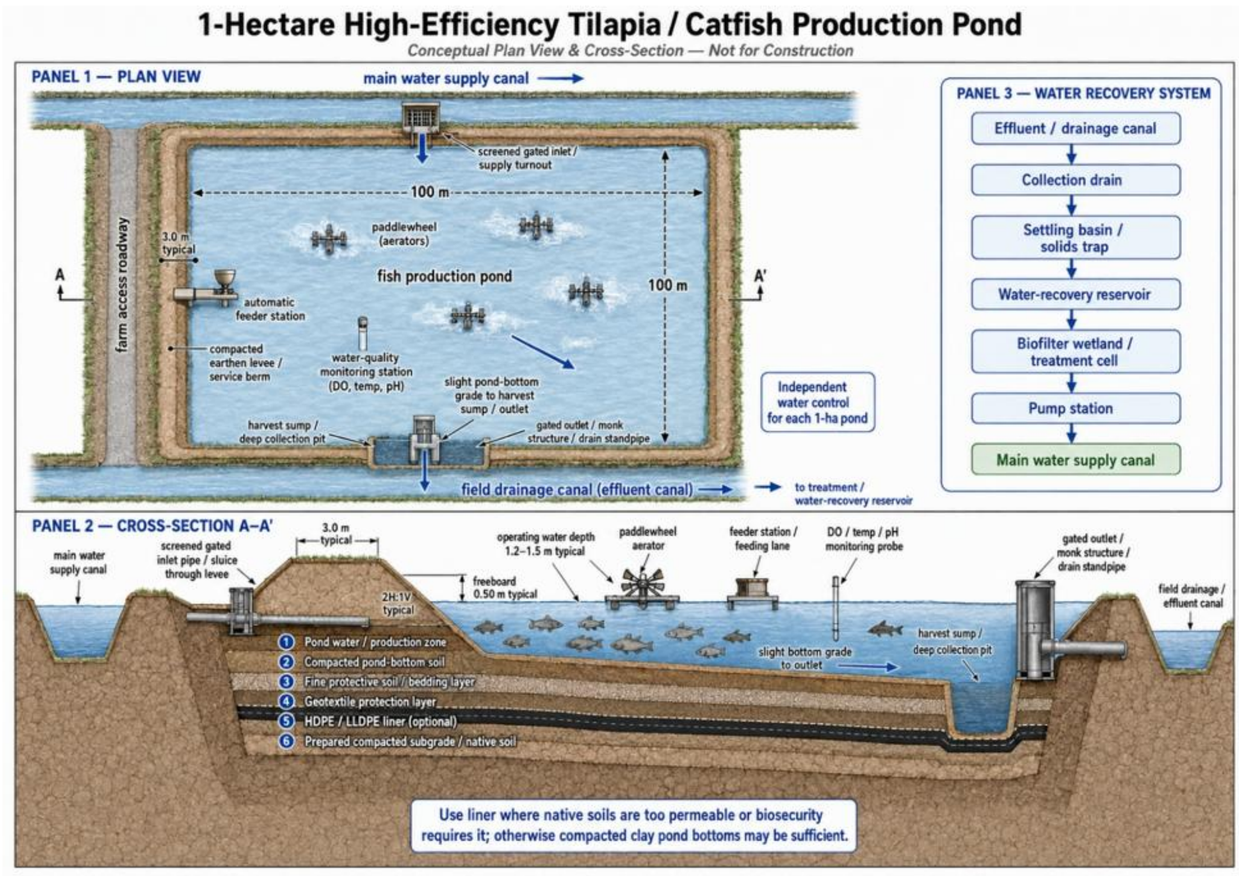
12.2 Water Quality Monitoring

- Per-pond minimum monitoring: dissolved oxygen, water temperature, pH, and water level.

- Farm/sector-level monitoring: ammonia, nitrite, alkalinity, turbidity, and conductivity/salinity where relevant.
- Connect monitoring points to telemetry so each pond reports as a managed production asset (e.g., DO, temperature, pH, depth, aerator status, feed delivered, estimated biomass) rather than being tracked only by periodic manual checks.

12.3 Feeding

- Install 2-4 programmable feeding locations per pound (blower, demand, mechanical broadcast, solar-assisted, or centrally controlled feeders) to distribute feed uniformly and minimize waste, since uneaten feed simultaneously wastes cost, raises organic loading, consumes oxygen, and increases ammonia and sludge.



13. BIOSECURITY SECTORING AND CENTRALIZED INFRASTRUCTURE

- Organize ponds/cells into 10-hectare production blocks, each with independent supply isolation, drainage isolation, feed storage, electrical panel, generator connection, water monitoring, equipment wash area, and fish-handling area, so a single block can be isolated if a health or water-quality issue occurs.
- Centralize the expensive, shared components rather than duplicating them at every hectare: fingerling nursery, feed storage/silos, laboratory, water-treatment system, standby-generation plant, harvest/processing facility, cold storage, and water-recovery system.

- Design solids management as a dedicated stream (pond -> effluent canal -> solids/settling basin -> water-recovery reservoir -> treatment -> reuse), with the settling basin accessible to equipment for periodic sludge removal.

14. TEAM ESTABLISHMENT AND FARM MOBILIZATION

7. Establish the farmer/technician teams that will tend the rice cells and the fishponds respectively, including cohort-based work assignments aligned with the staggered stocking/planting schedule.
8. Train teams on the AWD irrigation protocol and monitoring-tube/telemetry reading, the pond feeding and aeration protocol, water-quality monitoring procedures, and biosecurity/sector-isolation procedures.
9. Assign per-block responsibilities consistent with the biosecurity sectoring in Section 13, so accountability for water use, feed use, and yield is tracked at the cell and block level.

15. PLANT, EQUIPMENT, AND MATERIALS

Category	Typical Resources
Earthmoving & grading	Excavators, GPS/laser land-leveling equipment, motor grader, compaction equipment
Rice establishment	Seedling tray/mat nursery equipment, riding mechanical transplanter
Fish infrastructure	Paddlewheel/mechanical aerators, blower/demand/automated feeders, screens, monk/sluice structures
Water control	Isolation gates, flow-control valves, flow meters, standpipes, geomembrane (where required)
Monitoring & telemetry	AWD field-water tubes, water-level and soil-moisture sensors, DO/temperature/pH meters, telemetry/SCADA components
Power	Grid connection, standby generator(s), per-pond circuit protection
Harvest & logistics	Fish pumps, seine/lift-basket equipment, live-haul trucks, grain harvest/transport equipment
Site support	Central laboratory, feed storage/silos, cold storage, equipment wash area, workshop

16. MANPOWER AND ORGANIZATION

- Project Manager — overall responsibility for program, budget, and client/regulatory liaison.
- Irrigation/Civil Engineer — levee, canal, reservoir, and control-structure design and construction supervision.
- Agronomist — rice nursery, transplanting, AWD scheduling, and fertilization program.
- Aquaculture Manager — fish stocking, feeding, aeration, and water-quality program.
- Surveyor — precision grading control, benchmarks, and as-built survey.
- Water-Quality/Laboratory Technician — routine testing and telemetry oversight.
- Block/Sector Supervisors and farm technicians — day-to-day operation of assigned rice cells or fishponds.
- Electrical/Mechanical Technician — aeration, feeder, pump, and standby-generation maintenance.

- Community liaison — coordination with the local chief/District Assembly on land, labour, and water-source matters.

17. INDICATIVE SCHEDULE

Durations below are indicative for establishing a first 10-hectare production block (mixed rice and fish) as a pilot module, ahead of scaling to further blocks/sectors. Actual durations depend on the number of cells, reservoir sizing, and soil/permeability test results.

#	Phase	Duration	Dependency
1	Modular layout design & reservoir/canal design	Weeks 1–3	Reclaimed site handed over
2	Levy, road & canal construction	Weeks 3–8	Layout design approved
3	Precision grading (rice) / pond-bottom shaping (fish)	Weeks 6–10	Levy's substantially complete
4	Inlet/outlet/control structure installation	Weeks 8–12	Grading/shaping complete on that cell
5	Lining works (canals/reservoirs, and cells as required)	Weeks 9–13	Permeability testing complete
6	Nursery/hatchery setup & seed/fingerling sourcing	Weeks 8–12	Concurrent with structures
7	Transplanting / stocking of first cohort	Weeks 13–14	Cells commissioned
8	Team mobilization, training & handover to operations	Weeks 12–14	Concurrent with first cohort

Note: rice and fish infrastructure can be built in parallel across separate blocks; the pilot 10-hectare block is intended to validate AWD control, water recovery, and pond operation before infrastructure and stocking are replicated across further blocks/sectors.

18. QUALITY CONTROL AND MONITORING

Parameter	Purpose	Indicative Frequency
Cell/pond elevation survey	Confirm centimeter-level flatness (rice) or correct harvest-end grade (fish)	At construction sign-off, per cell
Soil permeability / geotechnical test	Determine lining requirement per cell/pond and levee design	Prior to construction, per zone
Flow metering (inlet/outlet)	Confirm water accounting per cell for AWD/aquaculture efficiency reporting	Continuous once commissioned
AWD water-level (surface/subsurface)	Confirm re-irrigation triggers are being met	Per cell, per irrigation cycle
Pond water quality (DO, temp, pH, level)	Confirm conditions remain within safe operating range	Continuous/daily per pond

Parameter	Purpose	Indicative Frequency
Farm/sector water quality (ammonia, nitrite, alkalinity, turbidity)	Confirm broader water-system health	Weekly, or per telemetry schedule

19. HEALTH, SAFETY, AND ENVIRONMENT (HSE)

- Site-specific HSE plan covering earthworks, confined/wet-area work, electrical (aeration/pump) hazards, and live-fish handling at harvest.
- PPE mandatory around canal, reservoir, and pond construction, and around electrical/aeration installations.
- Lock-out/tag-out procedures for aerator and pump maintenance; certified electricians for standby-generation and control-panel work.
- Emergency response procedure for levee breach, power/aeration failure (oxygen crisis in ponds), or major storm event, with defined escalation and nearest medical facility identified.
- Biosecurity protocols (foot baths, equipment disinfection, sector isolation) to limit disease spread between blocks.

20. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

- Water Resources Commission (WRC) Ghana permitting for water abstraction, reservoir construction, and any river diversion feeding the irrigation reservoir.
- EPA Ghana screening for effluent/discharge management from the return-water and solids-management systems.
- Evaluation of nutrient-reuse pathways (irrigated crops, forage, constructed wetlands, aquaponics) against food-safety and engineering requirements before adoption.
- Community engagement on labor sourcing, cohort employment patterns, and shared water-source management with neighboring land users.
- Documentation of water-use efficiency and, where relevant, methane-reduction performance of the AWD system for the client's own reporting or verification purposes.

21. KEY RISKS AND MITIGATIONS

Risk	Mitigation
Uneven grading defeats AWD control (partial flood/partial dry within a cell)	GPS/laser grading with permanent benchmarks and elevation verification before commissioning
Seepage through poorly compacted levees undermines water control	Engineered, tested compaction per civil/geotechnical design; permeability testing before lining decisions
Oxygen failure in intensively stocked fishponds	Redundant aeration, standby power, per-pond circuit protection, and continuous DO monitoring/telemetry
Serial (cell-to-cell) water flow spreads disease or water-quality problems	Independent inlet/outlet per cell; strict supply/drainage separation as designed
Storm event overtops levees during AWD drawdown	Drainage/outlet sizing based on extreme rainfall and catchment analysis, not AWD flow alone

Risk	Mitigation
Uneven fish size at stocking reduces grow-out uniformity	Separate hatchery/nursery/grading chain before stocking grow-out ponds

22. HANDOVER AND NEXT STEPS

On completion of the pilot block, the facility will be handed over to the operating teams with as-built drawings of the reservoir/canal/levee system, cell-by-cell elevation and permeability records, control-structure specifications, and an operating manual covering AWD scheduling, pond aeration/feeding protocols, and water-quality monitoring. A post-commissioning monitoring period through at least one full cropping/grow-out cycle is recommended before replicating the design across further blocks and sectors.

- Recommended immediate next steps: (i) confirm the number of rice versus fish cells planned for the first 10-hectare block, (ii) commission soil permeability testing to settle the lining strategy, (iii) confirm water source and WRC permitting for the raw-water reservoir, and (iv) convert this Work Program into a priced Bill of Quantities for contractor tendering.