Better management practices (BMPs) for grow-out farming of Genetically Improved Farmed Tilapia (GIFT) in Timor-Leste

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Partnership for Aquaculture Development in Timor-Leste Phase 2 (PADTL2)

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About Partnership for Aquaculture Development in Timor-Leste Phase 2 (PADTL2)

The Government of Timor-Leste is committed to developing aquaculture to improve the country's food and nutrition security while enhancing income opportunities for coastal and inland farming communities.

The Partnership for Aquaculture Development in Timor-Leste Phase 2 (PADTL2) (2020–2023) project aims to scale up production of Genetically Improved Farmed Tilapia (GIFT) to support progress toward the National Aquaculture Development Strategy (2012–2030). The strategy targets increased farmed fish production of 12,000 t per year by 2030 to raise annual fish consumption up to 15 kg per person. The project adopts a holistic approach to scaling up and out for impact, including by engaging and coordinating efforts with the private sector.

Project activities focus on increasing the access to and availability of quality seed, feed and grow-out technologies. This will help to increase the availability and accessibility of fish and encourage greater fish consumption. Phase 2 builds on the efforts laid by Phase 1 (2014–2019), which developed high quality seed and feed, trained farmers in better management practices and worked with ministry staff and the private sector to build their skills and knowledge.

The PADTL2 project is funded by the New Zealand Ministry of Foreign Affairs and Trade (MFAT) along with the United States Agency for International Development (USAID), which provided complementary funding in 2021 to support the achievement of the project's goals.

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List of abbreviations

ABW	average bodyweight
BMPs	better management practices
DAP	diammonium phosphate
DO	dissolved oxygen
FFS	farmers' field school
GIFT	Genetically Improved Farmed Tilapia
LSP	local service provider
MALFF	Ministry of Agriculture, Livestock, Fisheries, and Forestry
NADS	National Aquaculture Development Strategy
PADTL1	Partnership for Aquaculture Development in Timor-Leste Phase 1
PADTL2	Partnership for Aquaculture Development in Timor-Leste Phase 2
PPP	public-private-partnership
SMEs	small- and medium-sized enterprises
TSP	triple super phosphate

1. Introduction

Worldwide, the demand for fish continues to grow rapidly. To meet this demand, fish production systems will need sustainable intensification and expansion of aquaculture and innovations. In order to achieve sustainable growth, however, developing scalable aquaculture technology packages and better management practices (BMPs) interventions is necessary to narrow the fish demand-supply gap while maintaining a healthy ecosystem.

In Timor-Leste, the government has identified aquaculture as a way to improve food and nutrition security, diversify livelihoods of coastal and inland communities, and increase economic growth in the country. To tap into the sector's potential for development, the government, with assistance from WorldFish, developed its National Aquaculture Development Strategy (NADS) for 2012–2030. The strategy aims to boost fish supply from aquaculture to 12,000 t by 2030 and help reduce widespread malnutrition by increasing average annual per capita consumption of fish from 6.1 to 15 kg.

Nile tilapia (*Oreochromis niloticus*) is the world's second-most commercially cultured species group, after carps. It is a tropical fish suitable for year-round production in Timor-Leste, and Timorese like it because of its taste, versatility and affordability. Genetically Improved Farmed Tilapia (GIFT), which WorldFish has developed through selective breeding, is a fast-growing, hardy and resilient strain of Nile tilapia. It was first supplied to Timor-Leste in 2015 from WorldFish Headquarters in Penang, Malaysia, to the Gleno Fish Hatchery in Ermera. Since then, the hatchery has maintained its genetic quality by (i) following rotational breeding of GIFT cohorts, (ii) producing and disseminating high quality GIFT broodstock to public-private-partnership (PPP) model GIFT hatcheries and (iii) producing and disseminating monosex fingerlings to farmers. Altogether, there are four established PPP model GIFT hatcheries in Timor-Leste: Leohitu (Bobonaro), Parlamento (Lautem), Hera (Dili) and Colucau (Manufahi). All four are playing an instrumental role in increasing access to and availability of high quality monosex GIFT seed for farmers.

Along with establishing sustainable seed production and dissemination systems, WorldFish, in partnership with the Ministry of Agriculture, Livestock, Fisheries, and Forestry (MALFF), conducted on-farm testing and validation of sustainable GIFT farming technologies applying BMPs. These were carried out from 2017 to 2022 across four municipalities: Baucau, Bobonaro, Ermera and Lautem. They engaged over 160 farmers and employed a farmers' field school (FFS) approach, a group-based participatory learning method allows farmers to analyze a problem and reach a solution suitable for their local context.

In the initial years, WorldFish and the MALFF devised low-cost feeding and fertilization options based on locally available resources. With the adoption of these options, the FFS participants successfully realized an average extrapolated fish productivity of 4.3±1.5 t/ha/cycle. In 2021–2022, sustainable intensification of GIFT production systems by feeding fish high quality commercial feed pellets was tested and validated with 169 farmers (417 ponds) across all four municipalities. Farmers achieved an extrapolated fish productivity of 13.3 ±2.6 t/ha/cycle, resulting in over a 300% increase in fish productivity compared to previous cycles fed with farm-made feed based on locally available ingredients. This showed that GIFT can be successfully farmed in a diverse resource-base, and it can make a notable contribution to improving food and nutrition security and augmenting the household income of farmers in Timor-Leste. Farmers can adopt low-cost feeding and fertilization or sustainable intensification options by feeding fish high quality commercial feed pellets, depending on their resource-base.

Scaling successful GIFT farming technologies in the wider agroecological context is crucial for creating lasting impacts on the livelihoods of a large number of resource-poor households across Timor-Leste. Taking technical, social, economic and environmental aspects into account, this document provides BMP guidelines for scaling sustainable GIFT farming in the country. All stakeholders involved in promoting tilapia

aquaculture—from grassroots to the central level— can access and use this manual developed based on technologies and practices tested and validated in the country.

This manual is an updated version of the "Better management practices for Genetically Improved Farmed Tilapia (GIFT) in Timor-Leste" manual developed during Partnership for Aquaculture Development in Timor-Leste Phase 1 (PADTL1) project. It is one of the outputs of the PADTL2 project. The guidelines in this document are based on testing and validating GIFT farming technologies on-farm in Timor-Leste through the voluntary participation of all FFS participants for a number of production cycles across Baucau, Bobonaro, Ermera and Lautem. This BMP manual aims to enhance the capacity of grow-out farmers and extension service providers in Timor-Leste to help intensify and scale GIFT sustainably.

2. Why aquaculture in Timor-Leste?

2.1. Combating poverty and malnutrition through aquaculture

- Combating poverty and malnutrition has been the top priority for Timor-Leste.
- Animal-source foods (livestock and fish) play a vital role in a nutritionally balanced diet. However, meat is expensive and not readily available in rural areas of Timor-Leste, so aquatic products have become important to a nutritionally balanced diet in the country.
- The Timor-Leste government has identified aquaculture development as a means of improving food and nutrition security.
- The government's NADS envisions aquaculture contributing to improved food and nutrition security, the diversification of livelihoods of coastal and inland communities, and increased economic growth in Timor-Leste.

2.2. Why tilapia?

- Tilapia is the second-most farmed species group by volume globally.
- Nile tilapia is the most widely commercially cultured species in the world.
- Nile tilapia is a tropical fish, suitable for year-round production in Timor-Leste. It is a freshwater fish but can be farmed successfully in slightly brackish water (up to 10 ppt).
- Nile tilapia is a hardy and resilient fish that can tolerate low dissolved oxygen (DO) levels for short periods.
- Farming tilapia provides farmers with a greater return on their investment for a variety of reasons: (1) tilapia is an omnivorous fish that feeds on phytoplankton, periphytons, aquatic macrophytes, planktonic and benthic aquatic invertebrates, larval fish, detritus and decomposing organic matter, (2) it consumes formulated feed of both animal and plant origin, (3) it has a relatively short culture cycle (5–6 months), allowing farmers to harvest two crops in a year, and (4) consumers like it for its taste, versatility and affordability.

2.3. Why GIFT?

- GIFT is a fast-growing, hardy and resilient strain of Nile tilapia.
- Timor-Leste already has a state-of-the-art GIFT hatchery, which was established in 2016 by the MALFF with technical assistance from WorldFish.
- The hatchery has maintained genetic quality by following rotational breeding of GIFT cohorts and by producing and disseminating high quality monosex fingerlings.
- The PADTL1 and PADTL2 projects established four PPP model hatcheries between 2019 and 2023. These hatcheries acquire broodfish from the government hatchery, produce high quality GIFT monosex seed and supply them to farmers.
- Over 3000 farmers across Timor-Leste are currently farming GIFT. Demand for GIFT seed has continuously increased because of its quality and good on-farm performance.
- By farming monosex GIFT following BMPs, Timorese fish farmers are able to sustainably enhance the productivity and viability of aquaculture.

Plate 1. Incubating jars with tilapia eggs at the Leohitu hatchery in Timor-Leste.

Plate 2. Breeding, sex reversal and nursing ponds at the GIFT hatchery in Leohitu.

3. Organizing farmers into groups

- Organizing farmers into groups or clusters is an ideal approach for developing sustainable aquaculture at the level of small-scale or small- and medium-sized enterprises (SMEs).
- Tilapia production groups or clusters should be formed at the *suco* or *aldeias* level in suitable agroecological zones.
- Accessing inputs (seed, feed and fertilizers) and services (extension and market) becomes convenient when farmers are organized into groups or clusters.
- Sharing knowledge and providing technical support also becomes more efficient.
- Ideally, a farmers group should consist of 15–30 members.
- The group members should have at least one fishpond per household or group.
- Members should meet at least once a month to share their experiences with respect to the growth and performance of fish, and also to discuss any problems, potential solutions and future plans.

4. GIFT farming planning

- Aim for two production cycles a year (5–6 months per cycle).
- Tilapia is a warm water fish. The optimal temperature range for growth and reproduction is 25°C–30°C.
- Demand centers for fish should be identified either for local consumers, local demand centers (schools, hospitals, military/police barracks) or for retailers or supermarkets.
- Where appropriate, promote integrated agriculture-aquaculture systems to reduce the economic risk of crop failure and increase resilience among farming households.
- Choose from one of two intensification options, depending on the agroecological and resource-base contexts. One is for small-scale resource-poor farmers. It consists of using green water technology (i.e. enhanced phytoplankton growth fertilized with animal manure and chemical fertilizers) at a relatively low stocking density (3 fish/m^2) and giving fish farm-made feed. The other is for SME-level production systems. It consists of using the same technology but at a higher stocking density (5–7 fish/m^2) and feeding fish commercial feed pellets.
- Maintain a crop calendar and stick to it to ensure that stocking, production, harvesting and marketing of fish are done in a systematic way.

Plate 3. Integrated agriculture-aquaculture systems (IAAS): Fish-vegetables.

5. Economic viability

- Estimate the economic viability of the production system and check the availability of suitable land to dig a pond 100–500 m^2 or bigger.
- If the pond is 200 m^2, stock 1000 (5/m^2) fingerlings.
- Add about 3% extra (30) to compensate for loss during transportation.
- Work out the costs and potential profits before starting fish farming. If the business looks promising, then go for it.

- Estimated costs and benefits (green water technology, with fish fed with commercial feed pellets):
  - Seed = 1030 fingerlings x USD 0.03 = USD 31
  - Feed = 1030 x 0.3 kg x 1 feed conversion ratio (FCR) = 309 kg
  - Feed cost = 309 x USD 1.4 = USD 433
  - Other costs = USD 200
  - Revenue = 1030 fish x 90% survival x 0.3 kg x 4.5 = USD 1252
  - Gross margin = 1252 – (31 + 433 + 200) = USD 588
  - Gross margin % = 588/664 = 89% (which is very good compared to any other businesses)

6. Site selection

- Choose an area with a favorable resource-base and social and economic context for fish farming.
- Before selecting a site, ensure compliance with the environmental laws and land and water use policies of the country, as well as local cultural and social norms and regulations (e.g. *tara bandu*).
- Select a site for the pond in the area where
  - there is year-round availability of and access to freshwater for aquaculture;
  - the ponds can hold water well (DO NOT select an area with sandy soil);
  - the pond area is close to the homestead (where possible);
  - the area is not prone to flooding or drought;
  - the area is accessible by road to buy inputs and sell products.

Plate 4. Clay/loamy soil.

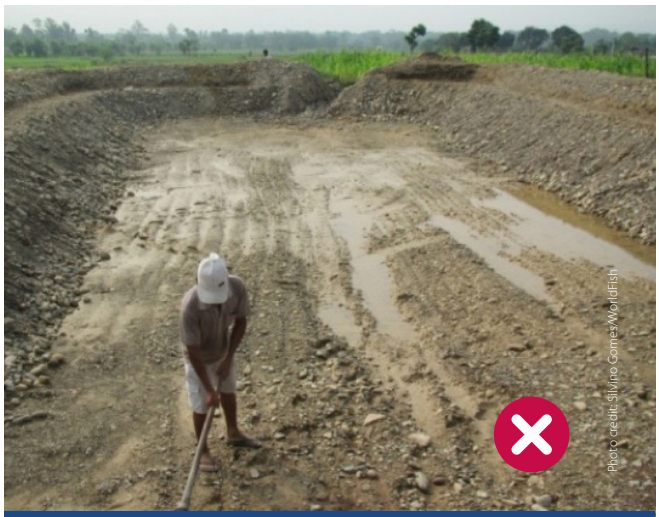


Plate 5. Sandy soil.

7. Pond design

- **Shape**: The shape of a pond can vary based on the land available. Square and rectangular ponds are both easy to build, though rectangular ponds are more practical to construct, feed and manage.
- **Size**: The size of a pond can vary from as small as 50 m^2 to 1 ha. From a management point of view, 200–1000 m^2 is an ideal size for conditions in Timor-Leste.
- **Depth:** Maintain a water depth of at least 30 cm at the shallow end and 1–1.2 m at the deep end. Ponds should be deeper in rainfed areas or areas without a reliable water supply so that they can hold sufficient water in the dry season.
- **Dike**: Elevate the dikes at such a level that floodwater cannot enter the pond. Slope the inner dikes at 1.5:1 m and the outer dikes at 2:1 m.
- **Inlet, outlet and overflow**: Regular water supply, drainage and overflow are all necessary for improved fish culture. Ensure the inlet and overflow pipes are at least 20 cm above the water surface to prevent fish from escaping.

8. Pond construction

1. Use an excavator to dig ponds or do it manually depending on size of the pond and availability of labor.
2. Use topsoil to make the dike. Use the bottom clay soil to make a layer of about 20 cm on the inner walls of the pond on all the sides and also at the bottom to stop any possible seepage.
3. If the soil is sandy and water seepage is high, use liners or make concrete ponds.
4. Build an access ramp for a vehicle on at least one side of the pond to facilitate transportation of inputs, fish, equipment and other materials.
5. Install an inlet pipe above the water surface and cover it with a fine mesh net to block insects and other fish from entering the pond.
6. Install an overflow pipe at the level of the water surface and cover it with a fine mesh net.
7. Install a drainage pipe in the deepest part of the pond to drain the pond completely.
8. Install a water gauge, and record the water level on a daily or weekly basis.
9. Maintain the crown of the dike wide enough (at least 50 cm) to walk around in order to feed the fish, monitor the water quality and handle the fish during harvest or other times, whenever necessary.
10. Use fine mesh nets to both fence the area around the pond to prevent snakes, ducks and other predators from eating the fish and also to cover the pond to keep out birds.

9. Pond preparation and management

9.1. Pond preparation

Follow these steps when preparing a new pond:

1. Dry the pond under the sun for at least a week.
2. Test whether it can hold water or not by filling it to about 20 cm. Check daily.
3. If the water disappears completely within a week, add clay soil to block the holes.
4. The pond is good if the water remains after a week.

Follow these steps when renovating an old pond:

1. Drain the water completely to get rid of predators and fish from previous crops in the pond.
2. Remove excess sludge and organic waste from the bottom, and then dry the pond for 1–2 weeks.
3. Renovate the dikes, and cut the weeds and grass on the dikes.
4. Check the water for leaks from the dikes or around the inlet or outlet, and block them by packing them with good clay soil.
5. Apply lime (preferably agricultural lime) to increase the pH of the soil and kill harmful organisms. The liming rate depends on the type of lime available (Table 1).
6. After liming, wait at least 3 days, then fill the pond completely with freshwater using filter nets over the inlet pipe.

9.2. Pond management

Managing a pond involves a daily routine that can include one or more of the following:

- Visit the pond twice daily, in the morning and afternoon.
- Observe the fish to make sure they are feeding actively and do not display any abnormal behavior, such as gasping at the surface of the water, swimming erratically or decreased swimming activity.
- Make sure the water depth is adequate and that the color of the water is green.
- Cut the weeds and grass on the banks of the pond.
- Ensure that screens over the inlet and outlet are in place and are not clogged or torn.
- Protect the fish from birds, frogs, snakes and other predators.
- Cover the ponds with a nylon net to protect the fish from birds if they are vulnerable.
- Do not allow animals such as cattle, buffalo, pigs and goats to graze on the dike of the pond.
- If there are big trees nearby, cut any branches that hang over the pond. The water might not turn green enough if the pond is under the shade. If any dead fish are found floating in the pond, record the numbers of dead fish, remove them right away and dispose of them safely by burying them.

Type of lime	Amount required (kg/100 m² pond)	
	New pond	Old pond
Agricultural lime, $CaCO_2$	10	5
Quick lime, CaO	5.5	2.5
Hydrated lime, $Ca(OH)_2$	7.5	3.5

Table 1. Liming rates.

9.3. Pond fertilization

- Tilapia like to feed on plankton. Fertilizers provide nutrients to stimulate the growth of plankton.
- Nitrogen and phosphorous are the major components in pond fertilization. They come from either organic manure (compost and manure from chickens, goats, pigs, cattle, etc.) or inorganic fertilizers such as urea and triple superphosphate (TSP) or diammonium phosphate (DAP).
- Choose organic manure, inorganic fertilizer or a combination of both to fertilize the pond and enhance natural food (plankton).
- Apply organic manure.
- Initially, apply fertilizer and/or manure weekly at a rate of 600 g of urea, 300 g of TSP or DAP and 20 kg of chicken manure per 100 m^2 (Table 2).

Dissolve inorganic fertilizers in a half bucket of water before applying them into the pond: as follows

- Adjust the fertilization rates and frequency of fertilization based on the plankton density in the pond.
- Maintain the plankton density within a suitable range so that the pond stays light green.
- When the water becomes dark green, reduce the fertilization rates by half to maintain a light-green color in the pond (Secchi disk reading of 30–40 cm).
- If the water becomes dark green, do not fertilize the pond for a week.
- Maintain a water depth of about 1–1.2 m by topping up the water to replenish water loss from evaporation and percolation.
- Place organic manure in a corner of the pond.

Type of fertilizers	Amount per 100 m^2 pond
Urea (g)	600
TSP/DAP (g)	300
Chicken manure (kg of dry matter)	20

Table 2. Fertilization rates.

Plate 6. Properly dried pond.

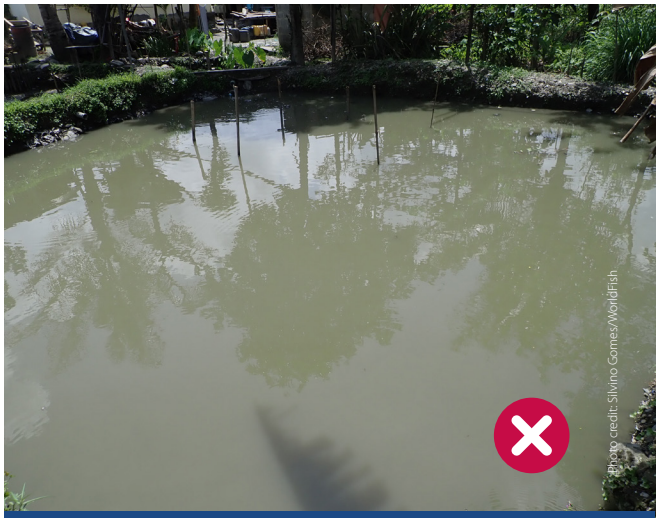


Plate 7. Undried pond.

Plate 8. Black soil removed.

Plate 9. Black soil not removed.

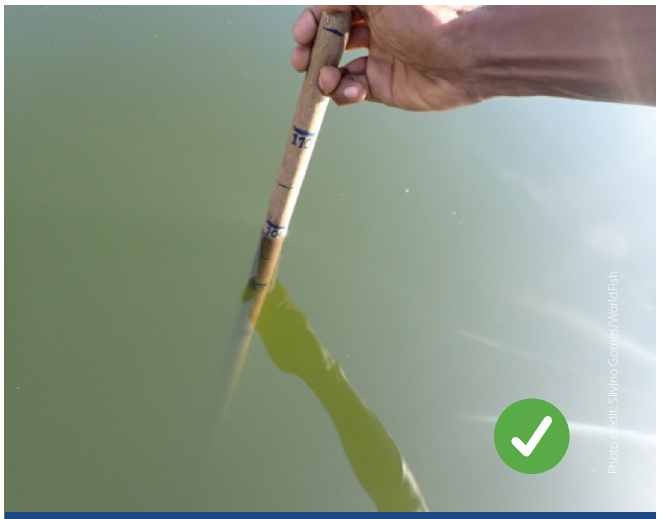


Plate 10. Adequate water depth.

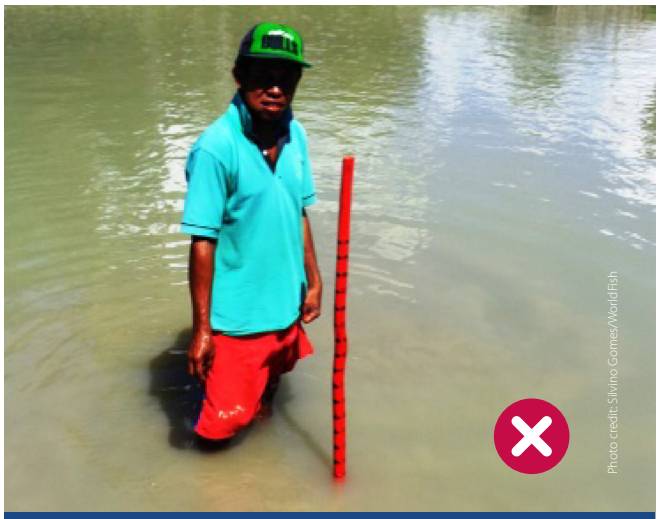


Plate 11. Shallow pond (inadequate water depth).

Plate 12. Application of lime.

Plate 13. No lime application.

Plate 14. A pond with periphyton sticks.

Plate 15. Turbid water.

Plate 16. Manure application.

Plate 17. Manure application.

Plate 18. Small seed.

Plate 19. Large and uniform size monosex fingerlings.

Plate 20. Proper seed packaging.

Plate 21. Transportation during morning or evening.

Plate 22. Releasing fingerlings into the pond.

Plate 23. Fish farmers holding GIFT fingerlings in bags at Colocau hatchery.

10. Seed selection and stocking

- Acquire good quality GIFT fingerlings of similar age and uniform size for stocking. Usually, fingerlings about 4–5 weeks old with an average weight of at least 3 g are suitable for stocking.
- For faster growth, stock all male (monosex) tilapia seed of uniform-size for better productivity and profitability.
- Always acquire GIFT seed from a reliable hatchery or nursery with a proven track record.
- If the fingerlings are small, nurse them in a hapa placed in the pond and release them into the pond once they reach at least 3 g in size. Nursing them will reduce the mortality of the fingerlings.
- Prepare and transport fingerlings during the cool hours of the day, preferably in the late afternoon or early morning.
- Float the seed bags on the surface for 20–30 min to acclimatize the fingerlings to the temperature of the water before releasing them into the pond.
- Stock monosex GIFT fingerlings at a rate of 3–7/m^2 (for extensive to semi-intensive culture systems), depending on the water quality and feeding system.

11. Feed management

Tilapia grow faster in fertilized ponds when given supplemental feed. Depending on cost and availability, feed tilapia with floating pellets, sinking pellets or farm-made feed based on locally available ingredients.

11.1. Farm-made feed

- A cost-effective option for homestead tilapia production systems for household consumption is a combination of farm-made feed for feeding along with fertilizers for pond fertilization.
- Cornmeal, rice bran, leucaena leaf meal, taro leaf meal and cassava are plant-based ingredients that farmers can use for on-farm feed preparation from different combinations, as shown in Figure 1.
- Pre-treatment is required for some of the ingredients before using them in the feed. Soak leucaena leaves in water for 2 days, let them dry in the sun and then grind them into powder. Dry taro leaves in the sun and then ground them finely.

11.2. Commercial feed pellets

- Feeding fish high quality commercial feeds with over 30% crude protein is important for increasing productivity and shortening the grow-out period.
- Floating fish feed pellets are better options than sinking pellets. A significant proportion of sinking pellets is wasted, as they get deposited on the pond bottom.

Take the follow points into consideration for feeding fish:

- Feed the fish twice daily, at least 6 days a week.
- Give them an adequate amount of feed by following a feeding guide based on the weight of the fish.
- As shown in Table 3, use monthly sampling to set the amount of feed according to the total weight of the fish in the pond, and increase the amount as their weight increases.
- Weigh the feed for the proper amount needed at each feeding time.
- Always feed the fish at the same place and same time.
- Use a feeding tray or frame for floating feed and a feeding tray for sinking feed to confine the feed in a certain area and minimize waste.

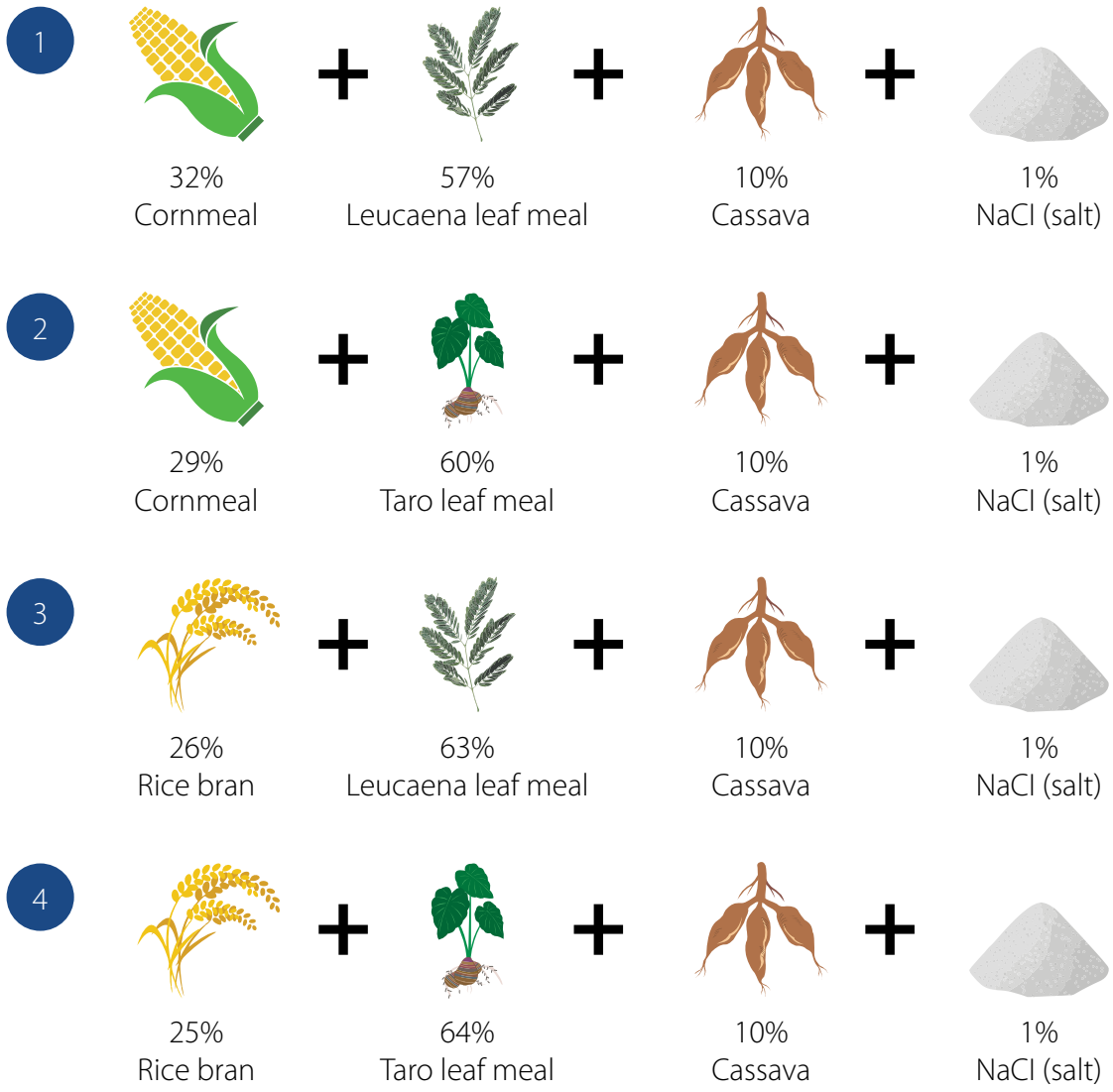


Figure 1. Major feed formation options based on locally available ingredients.

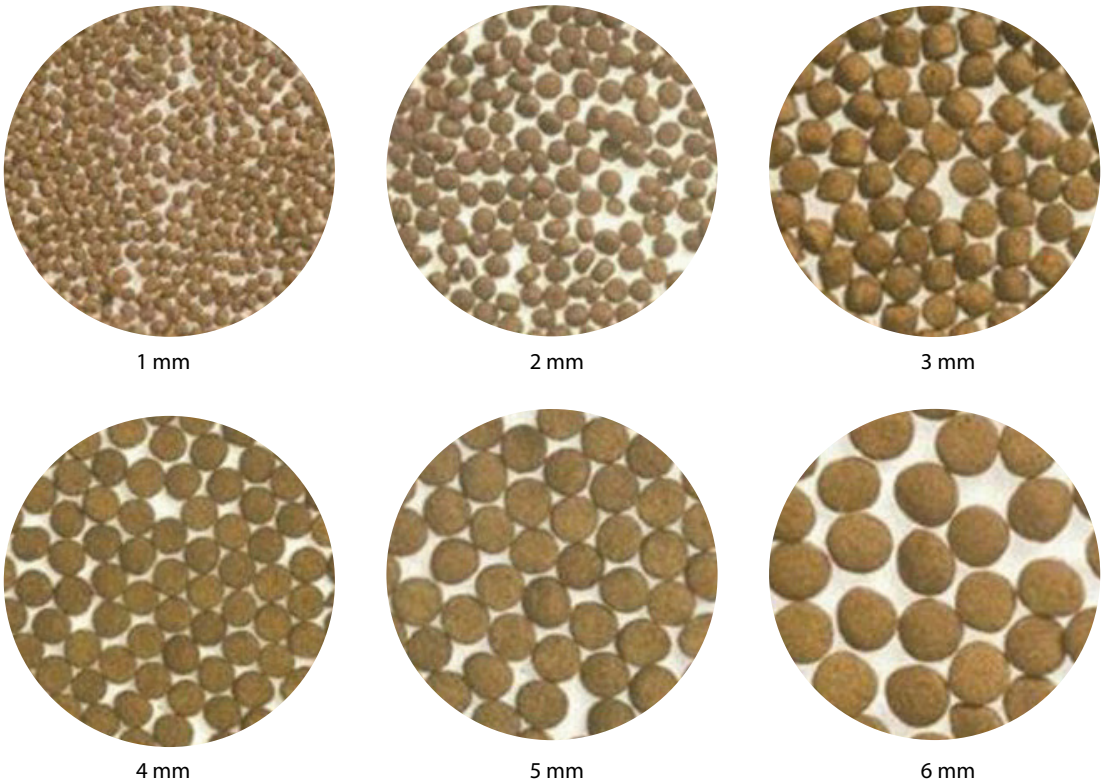
- In large ponds, spread feed over a wide area of each pond. This ensures each and every fish can access the feed without much competition.
- Feed the fish slowly by throwing pellets little by little; do not dump the feed all at once and then go. Wait at least 15 min to see how the fish eat.
- Do not overfeed the fish. Too much uneaten feed at the bottom of the pond will pollute the water. Overfeeding also increases the production cost.
- If the fish do not eat all of the feed within an hour, give them a little less the next day.
- If the fish eat all of the feed very quickly, give them a little more the next day.
- If the weather is rainy and cloudy and the fish are coming to the surface gasping for air, stop feeding and either add water or aerate it.
- If using pellet feed, select the proper size based on the size of the mouths of the fish so that they can eat the pellets easily.
- Tilapia are not very active during the night, so do not feed them after the sun sets or before it rises.
- The best feeding times are 08:00–0:900 and 16:00–17:00 for twice daily feeding. If feeding is done three times a day, add a third feeding time around noon.
- Sample the fish to estimate the biomass and feed amount, and calculate the amount of feed required as described in Section 13.
- Split the daily amount of feed into two meals if feeding is done twice a day and into three meals if done three times a day (e.g. 900 g/3 = 300 g)

- Make a cup from an empty plastic water bottle to accommodate 300 g, then use that cup to take feed out from the feed bucket each time you feed the fish for those 2 weeks.
- Adjust the feeding rate every 30 days after sampling the fish.
- As the fish grow bigger each month, change the size of the cup according to the increase in feed.
- Floating feed is better, as tilapia like to eat from the surface. Since floating pellets are expensive, however, farmers might want to prepare sinking pellets themselves or buy them from the local market. If using sinking feed or a type of dough feed, use a tray when feeding the fish.
- Generally, feed pellets for tilapia range from 1 to 8 mm in size. Use smaller pellets when fish are small and increase the size of the pellets as the fish grow.
- The amount of feed needed depends on the stocking density, target size and weather conditions.
- Refer to Table 3 to work out the amount of feed.

Age of fish (days)	Expected fish size (g)	Pellet size + (mm)	Feeding rate (% biomass/day)	Daily feeding frequency
0–30	3	Powder*	3	3
31–60	20	1	3	3
61–90	75	2	2.5	2
91–120	135	3	2	2
121–150	200	4	1.5	2
151–180	300	4	1	2
181+	>350	5	1	2

** If powdered feed is not available, crush the pellets with a grinding machine.*

Table 3. Guideline for feeding tilapia at 24°C–30°C using formulated feed.



Source: www.pelletmillsolution.com.

Figure 2. Different sizes of pellets.

Plate 24. Farm-made feed preparation.

Plate 25. Commercial floating feed pellets at the shop of a local service provider (LSP).

Plate 26. Applying feed into the pond.

12. Water quality management

12.1. Water temperature

- A suitable water temperature range for tilapia is 20°C–32°C. Measure the temperature of the water source before starting to dig the pond to make sure the water in the area has a suitable temperature.
- After stocking the fish, measure the temperature of the pond water every week by taking two measurements on the same day: one at 06:00 for the lowest temperature and at 14:00 for the highest temperature.

Plate 27. Measuring pH and temperature.

12.2. Dissolved oxygen

- Maintaining an adequate DO level is crucial. Make sure it stays higher than 5 mg/L but no lower than 2 mg/L in the early morning.
- If oxygen levels in the pond are low, the fish will come to the surface and start gasping, especially early in the morning.
- If the fish are gasping for oxygen (at night, early in the morning or even during the day on a cloudy day), pump and spray water over the pond with a hose to add oxygen into the water.
- Smallholder farmers without access to a pump can use a bamboo or wooden pole to stir the pond water and create a ripple effect to increase the level of DO. If necessary, replace some of the water.

Plate 28. Secchi disk reading.

12.3. pH

- Maintain a pH of 7–9 for the pond water.
- Check the water pH weekly at 09:00, whenever a pH meter is available.
- If the pH is lower than 6, apply lime to increase it (Table 1).
- If the pH is higher than 9, add or replace the water to lower it.

Plate 29. Water quality monitoring kit.

12.4. Water color and Secchi disk reading

- Maintain a light-green color in the pond water.
- Maintain a Secchi disk reading of 30–40 cm for water transparency.

12.5. Water quality test kits

Water temperature, DO, Secchi disk visibility and pH are very important parameters for maintaining water quality. Monitor these with simple portable equipment on a daily or weekly basis at 06:00 and 14:00 on the same day. Optimal parameters and their ranges for tilapia are shown in Table 4. Take appropriate actions immediately if these parameters are below or beyond their ranges.

Parameters	Optimum	Optimal range
Temperature (°C)	30	28–32
DO (mg/L)	7	4–10
pH	7.5	6.5–9
Salinity	0	0–15
Ammonia	0	0–2
Nitrite	0	0–0.2
Nitrate	0	0–1

Table 4. Optimal water quality parameters of pond water for GIFT.

Plate 30. Sampling fish to estimate the feed requirements.

13. Sampling fish and monitoring growth

Sample the fish periodically to monitor their growth, adjust feeding rates and to plan harvesting.

To sample fish, follow these steps:

1. Sample the fish either in the morning or late afternoon to avoid heat stress.
2. Throw a cast net into the pond and try to catch at least 10–15 fish at a time.
3. Weigh them all at once, then count and release them back into the pond as soon as possible.
4. Catch fish from three different locations in each pond for replication.
5. Sample the fish once every 30 days to estimate the growth rate.
6. Multiply the average size of the fish by the total number stocked, deducting any mortalities, to estimate the total fish biomass in the pond.
7. Calculate the daily feed ration by multiplying by the recommended percentage for the month.
8. Use a method that does not disturb the pond bottom excessively.
9. Calculation:

$$\text{Average weight (g)} = \frac{\text{Total weight of a random sample of fish (g)}}{\text{Number of fish in the sample}}$$

$$\text{Total biomass (kg)} = \frac{\text{Average weight (g) x total number of fish stocked in the pond}}{1000}$$

Sample	Bulk weight (kg)	Number of fish	Average weight (g)
1	1.5	28	53.6
2	1.2	25	48.0
3	1.3	22	59.1
Total	4.0	75	160.7
Average	1.3	25	53.6
Standard deviation	0.2	3	5.5

Table 5. Calculating the average size of the fish.

Plate 31. Regular fish sampling.

Plate 32. Growth check.

14. Fish farming options

As shown in Table 6, there are a number of options for farmers when it comes to how they want to manage their fish farming business. A farmer can adopt a low-cost production method using homemade feed or kitchen waste, such as leftover rice or bread, or they can choose to feed their fish with high quality feed following the recommended feeding rates (Table 3) depending on their resource-base and objective. Farmers who give their fish high quality commercial feed pellets can achieve three to five times more productivity from the same area of the pond compared to those using homemade feed or kitchen waste.

Fish farming system	Stocking density (fingerlings/m^2)	Daily feeding rate (% of weight)	Expected production (t/ha/cycle)
Extensive	2–3	<1*	4
Semi-intensive 1	4–5	3.5 → 1.5	12
Semi-intensive 2	6–7	3.5 → 1.5	16
Intensive	8–10	4 → 2	20

** Limited amount of homemade feed, one or two times a day.*

Table 6. Farming options for farmers based on the level of management.

15. Fish health management

- Nile tilapia is hardier and more resistant to disease than other commonly cultured freshwater fish species, as long as the pond water is kept within the optimal temperature range (18°C–36°C).
- A disease outbreak usually occurs when fish are exposed to stress, such as high water temperature, low DO levels or overcrowding in a pond for a long period.
- There are a number of preventive measures farmers can use to reduce the risk of diseases and parasitic infections:
  - Stock the pond with healthy, disease-free seed.
  - Disinfect all tools used in fish culture operations.
  - Avoid overcrowding.
  - Follow proper feeding, fertilization and water quality management practices.
- Conduct routine screening for any sign of disease or stress.
- Note and photograph all clinical signs, and record the number of dead fish. Remove all moribund and dead fish and bury them far away from the pond.
- Bring any unusual mortalities to the attention of the responsible authorities, and help them collect sick and moribund samples for laboratory testing.
- Follow the recommendations of the responsible authorities for disease management.

Common clinical signs of diseases and parasitic infections in tilapia include the following:

- Fish eat less or stop feeding entirely.
- Lesions or hemorrhages appear on the body.
- Tail and fins begin to rot.
- Gills become pale and damaged.
- Cotton- or wool-like fungi appear on the body.
- White spots appear on the body and fins.
- Black and white spots or cysts form on the gills.
- The growth rate decreases.
- The fish show signs of physical weakness, bent bodies and fatigue.
- The fish begin to swim in circles, lose their balance and float upside down.
- A reddish pigmentation forms around the anus or on the genital papilla.
- Hemorrhages appear on the eyes and skin.
- Eyes become cloudy and opaque.
- The belly becomes swollen from dropsy.
- Internal organs such as the liver, kidney, gall bladder and spleen begin to swell.
- The fish empty their stomachs.

Plate 33. Eye opacification.

Plate 34. Skin erosions and hemorrhagic lesions.

Plate 35. Abdominal distension/swelling.

Plate 36. Scale protrusion/detachment.

Plate 37. Open wounds.

Plate 38. Fish gasping at the surface.

16. Harvesting

- Harvest fish 5–6 months after stocking when they reach about 300 g in size.
- Follow a single or multiple harvesting strategy, depending on preference, market demand and the density of fish in the pond.
- Coordinate the harvest with other farmers.
- Stop fertilizing the pond 2 weeks before harvesting.
- Do not feed the fish the day before the harvest to allow them to empty their stomachs. This will improve the survival and condition of the fish during handling.
- Harvest early in the morning when the water is cool. This will reduce the amount of stress on the fish while they are being seined or collected.
- Prepare all equipment in advance: aeration (if selling live fish), inflow of clean water, holding tanks, hapas, hammocks, buckets, quality ice, seine nets, scoop nets, etc.
- To effectively harvest tilapia in ponds, make sure several people are on hand. Tilapia are clever at escaping seine nets by burrowing into the pond bottom or slipping under them. Stretch the seine net from dike to dike and haul it gradually.
- Even with several people, harvesting more than 40% of the tilapia per seine haul is difficult. To harvest all the fish in the pond, seine the water three or four times and then drain the pond completely.
- Complete the harvesting process within 1–3 hours.
- Estimate the fish biomass at least a week in advance, when the fish are ready for sale.
- Sample (Section 12) the fish to estimate the total biomass before sale, especially when harvesting is done on a contract basis. Estimate the fish biomass as follows:
  Total stocked fish = 1000
  Expected survival = 90%
  Total biomass = 1000 x 0.90 x 300 = 270 kg
  Estimated revenue of USD 4/kg = USD 1080
- Start draining the pond 1 day beforehand to make it easier to harvest the fish.
- Use a seine net of required mesh size based on the size of the fish to harvest.
- If all the fish cannot be sold at the same time, harvest the fish partially in multiple batches. Harvest larger fish first and leave the smaller ones in the pond to grow larger for the next harvest.
- If doing a full harvest, drain the pond completely and collect all the fish from the pond. Tilapia can hide in the mud, so be sure to check and collect them all.
- Complete the harvest within 1–2 hours.
- Collect the harvested fish in a hapa installed in the pond for selling live fish.
- Grade the harvest according to small, medium, large and very large fish, and sell them at different prices based on these sizes.
- Maintain uniformity in each pack. Customers will pay more for good packaging.
- Use a container mounted on a pickup truck with water and aeration if the fish are sold live. Otherwise, transport the fish quickly so that they are still fresh when they arrive at the market.
- Try to receive payment in advance while booking or on the day of the harvest.

Plate 39. Fish harvest.

17. Post-harvest handling

- Handle the fish in the morning or under shade, and use an aeration system or lots of flowing water.
- If the fish are crowded into containers for a long time, make sure the water is clean and has an aeration system or running water flowing through it.
- If an aeration system is not available, do not overcrowd the fish in small containers. If the fish are coming to the surface to gasp for oxygen (piping), this is a sign of overcrowding. If this happens, add clean water from a tap or reduce the number of fish per container.
- When handling the fish, use scoop nets made of soft material to avoid bruising them. Seine nets should be made of fine mesh, as coarse mesh nets will trap the fish by their gills and cause injury.
- Handle the fish gently; avoid dropping them on the ground or leaving them out of the water.
- While holding or carrying adult fish, cover their eyes with one hand so that the fish will remain calm.
- Tilapia have sharp spines on their fins. Wear gloves to avoid hand injuries during catching.
- After washing, dip the harvested fish in a slurry of ice for no less than 15 minutes. If possible, use fresh water to make the ice slurry. Do not use dirty pond water. This process improves freshness.
- Be sure to use good quality ice, prepared with treated potable water, during harvesting and packaging.
- Pack the fish with crushed ice in transportation tubs (insulated boxes) at a 1:1 ratio for better preservation.
- Before stacking the packed crates on top of one another, make sure the bottoms are clean. Always maintain cleanliness.

Plate 40. Harvested fish with crushed ice.

Plate 41. Harvested fish without ice.

18. Processing and product development

When fish cannot be sold fresh or if prices fall, farmers can process fish to increase their shelf life, as processed fish-based products can be stored for a longer period. Processing farmed fish is not common in Timor-Leste, but aquaculture in the country has the potential to produce diversified fish-based products in the near future.

The following are the main fish processing techniques that could be adopted in Timor-Leste:

- **Sun-drying**: Cut the fish, take out the viscera and open the two sides so that the moisture can evaporate easily in a day or two under the sun. If using a greenhouse, fish can dry quickly, making it possible to produce a large volume of products to sell in different markets.
- **Smoked fish**: Cut the fish, take out the viscera and open the two sides to smoke the entire area. Hot smoking is popular in Asia.
- **Fish powder**: Fry the fish in oil or ground them to make powder. Various brands of powders with good packaging and labeling are found throughout Asia. Use local materials to package the fish.
- **Fish paste**: This is an indigenous technique using spices. Use local materials, such as tree or banana leaves, for packaging.
- **Fermented fish**: This is a traditional method of preservation practiced in Southeast Asia. Degut the fish, rub them with salt, rice bran and other condiments, and keep them under pressure to lower the pH and prevent bacteria from growing.
- **Frozen fish**: Keep the fish on ice or in a refrigerator at 0°C or lower, whether whole, as fillets or cut pieces.
- **Fish fillets**: Tilapia do not have intra-muscular bones, making it easy to produce fillets for sale at supermarkets with good packaging and labeling.

Plate 42. Sun-dried tilapia (degutted and bifurcated).

Plate 43. Sun-dried tilapia (whole body deheaded and degutted).

Plate 44. Fish powder with different flavors (normal, spicy and herbal).

19. Marketing

Tilapia can be sold in several ways based on market demand:

- live
- whole and fresh (sold soon after harvesting)
- whole and on ice
- whole and frozen (gutted before freezing)
- filleted (fresh or frozen)
- smoked or dried
- fried or cooked in the local custom.

The following are improved marketing practices:

- Start marketing when fish weigh more than 200 g.
- Check the prices of fish in different local markets or restaurants for various sizes. If the prices do not vary by size, sell the smallest possible (e.g. 200 g or so).
- Sample the fish, take some pictures and advertise on social media before harvesting to get advanced bookings rather than harvesting fish and waiting for customers.
- Farmers groups can join together to market farmed tilapia and ensure a consistent supply of fish to live fish shops and Dili and municipalities, as well as other fish demand centers, such as schools, hospitals and police/ military barracks.

Harvest only the amount of fish that you can sell on the same day, and sell them as soon as possible. It might be good to harvest fish on Fridays, special occasions or festivals, when people want to buy fish and celebrate.

- Organize a fish marketing campaign (through social media, FM radio, local TV) to increase awareness of your fish among buyers.
- In Timor-Leste, weekly farmers' markets are a great venue for selling fish to local consumers.

Plate 45. Fish put on ice after harvesting.

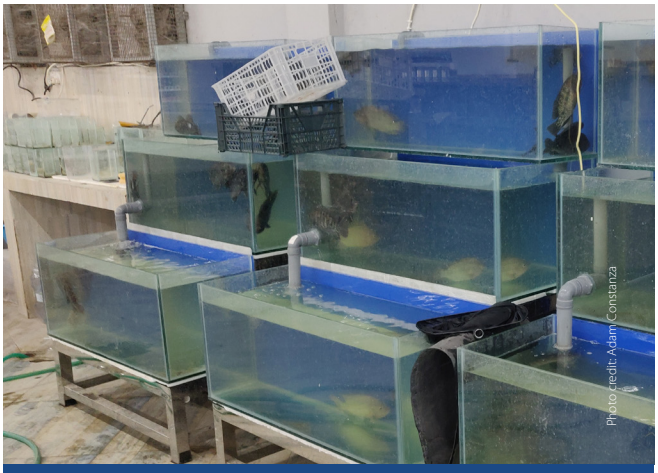


Plate 46. An LSP selling fresh tilapia in their local area.

Plate 47. Earning an income from fish sales.

20. Recordkeeping

- Maintain a pond record book (one book per pond) for recording all activities, including stocking date, stocking number and size, feeding, fertilizing, quality management, clinical signs, mortality numbers, harvesting, harvest size and weight, marketing, etc.
- Keep a daily logbook to help analyze crop performance, possible causes of crop failure, low productivity, etc.
- Keeping records of input costs and returns helps farmers improve the economic efficiency of their fish production system.

Keep the following records in a logbook for each pond over a complete production cycle:

- **Pond**: pond information/dimensions, inputs for pond preparation
- **Stocking information**: source of fingerlings, stocking date, total stock number, average size of fingerlings
- **Feed**: feeding practice info (including source of feed), specific types of on-farm inputs (e.g. rice bran, corn bran, etc.), expenses, market price, feeding rate, total amount of feed used (kg)
- **Fertilization**: fertilizing practice info, including source of fertilizer, quantity applied (kg), frequency and expenses (if bought from market)
- **Water quality**: depth, color, Secchi disk reading, temperature, DO and pH
- **Fish growth and health monitoring**: periodic sample length and weight (for every sample), mortality rate, gross clinical observations (if any)
- **Harvesting**: total number and weight of fish harvested, total fish consumed, total fish gifted, total sold and market price per kilogram
- **Labor**: total amount of labor used per cycle and total wages.

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Appendix: Pond record book

National Directorate of Fisheries and Aquaculture
Ministry of Agriculture and Fisheries
Dili, Timor-Leste

Partnership for Aquaculture Development in Timor-Leste Phase 2
Fish farmer pond and input-output record book

Record year: from _____ to _____

Pond identification number (ID): _____

July 2023

Funded by

NEW ZEALAND FOREIGN AFFAIRS & TRADE Aid Programme

USAID FROM THE AMERICAN PEOPLE

Implemented by

WorldFish CGIAR

In partnership with

Sketch a map of all the ponds in the farm on this page:

1. Assign a number to each pond.
2. Record the dimension for each pond (width x length).
3. Specify fish strains in each pond (GIFT or others).
4. Highlight the pond referred to in this pond book.

Farmer/cluster information

Cluster:		
Family/group leader name:		
Group or family members Note: Select either group or family. If family, write your relation to the household head in parentheses (wife, son, etc.)	1. 2. 3. 4. 5.	6. 7. 8. 9. 10.
Municipality:	Sub-municipality:	
Suco:	Aldeia:	
Project intervention:	Monosex GIFT technology	
Date of enrollment of farmer/group in the project:		

Pond information (one record book per pond)

Pond identification number (ID):	Pond GPS coordinates (latitude/longitude):
Type of pond: earthen/cement	Pond area in meters (length x width):
Average depth of pond:	Highest: _____ m Lowest: _____ m
Year of construction:	Year last used for fish farming:

Pre-stocking information, by pond

Date (year/mm/dd)	All activities done before stocking GIFT seed*	Name/type of inputs used	Amounts of inputs used (kg/person or hour)**	Cost of inputs (USD)	Source (on-farm/market)

* *Examples of activities: digging the pond, removing sludge, drying the pond, liming, filling the pond with water, fertilization, etc. Examples of inputs: labor, lime, organic manure, inorganic fertilizers, etc.*

** *If the input is feed or fertilizer, the unit is kg per week; if the input is labor, the unit is person day per week.*

GIFT seed stocking information

Date	Number of seeds (n)	Size (g)	Source/ hatchery name	Purchase price (USD)	Mode of transportation	Number of dead fry within 1 day of stocking	Water color in the pond*	Remarks

**Examples of water color: clear, light green, green, dark green, turbid, brown, dark brown.*

Monthly fish sampling, by pond

Day	Sample 1			Sample 2			Sample 3			Average (X+Y+Z)/3
	Weight (W) = (g or kg)	Number (N) = fish	Avg (X) = W/N	Weight W= (g or kg)	Number N= fish	Avg (Y) = W/N	Weight W= (g or kg)	Number N= fish	Avg (Z) = W/N	
Day 0 or at stocking (data from hatchery)										
Day 30										
Day 60										
Day 90										
Day 120										
Day 150										
Day 180										
Day 210										
Day 240										

Weekly feeding information

Week	Feed type used (% of protein)	Source	Feeding frequency per week	Quantity used per week (kg)	Expenses (USD)	Remarks
Week 1						
Week 2						
Week 3						
Week 4						
Week 5						
Week 6						
Week 7						
Week 8						
Week 9						
Week 10						
Week 11						
Week 12						
Week 13						
Week 14						
Week 15						
Week 16						
Week 17						
Week 18						
Week 19						
Week 20						
Week 21						
Week 22						
Week 23						
Week 24						
Week 25						
Week 26						
Week 27						
Week 28						
Week 29						
Week 30						
Week 31						
Week 32						

Weekly management and labor information

Date	Number of hours	Type of activity*	Laborer (husband, wife, kids, etc.)	Wage rate per hour	Total value of labor (USD)	Remarks
Before stocking						
Week 1						
Week 2						
Week 3						
Week 4						
Week 5						
Week 6						
Week 7						
Week 8						
Week 9						
Week 10						
Week 11						
Week 12						
Week 13						
Week 14						
Week 15						
Week 16						
Week 17						
Week 18						
Week 19						
Week 20						
Week 21						
Week 22						
Week 23						
Week 24						
Week 25						
Week 26						
Week 27						
Week 28						
Week 29						
Week 30						
Week 31						
Week 32						
Week 33						
Week 34						
Week 35						
Week 36						

**Examples: constructing the pond, filling the pond with water, liming, fertilization, transporting fry, stocking, feeding, harvesting, selling, etc.*

Other weekly husbandry practices information

Date	Input used*	Source (on-farm/market)	Frequency per week	Quantity used per week (kg/ person day)	Method/description (how they are used)	Expenses (USD)	Remarks

**Examples of inputs: labor, lime, organic manure/fertilizer, inorganic fertilizer, etc.*

Weekly water quality information

Week	Water color (clear, light green, green, dark green, turbid, brown, dark brown)	Secchi disk/hand reading (cm)	Water depth (cm)	Remarks
Week 1				
Week 2				
Week 3				
Week 4				
Week 5				
Week 6				
Week 7				
Week 8				
Week 9				
Week 10				
Week 11				
Week 12				
Week 13				
Week 14				
Week 15				
Week 16				
Week 17				
Week 18				
Week 19				
Week 20				
Week 21				
Week 22				
Week 23				
Week 24				
Week 25				
Week 26				
Week 27				
Week 28				
Week 29				
Week 30				
Week 31				
Week 32				
Week 33				
Week 34				
Week 35				
Week 36				

Biweekly health monitoring information

Date	Occurrence of mortality (yes/no)	Number of dead fish	Observations (if any)*

**Examples of observations: active, swimming normal, no visible abnormality, coming to surface, gasping in early morning, damaged fins, blood spots on body surface, open wounds, abnormal swimming, etc.*

Harvesting, consumption and marketing information (every harvest)

Date	Quantity harvested (number)	Amount harvested (kg)	Amount consumed in household (kg)	Amount gifted (kg)	Amount sold (kg)	Market price per kilogram if sold (USD)	Total value in USD (kg x Y)	Remarks: Provide additional information (e.g. Did you observe any fingerlings that resulted from spawning?)
Total								

Income and expenditure (calculated at the end of crop by facilitator)

Production value	**Total value (USD)**	**Percentage of total (x or y or z /A*100)**
Value of consumed fish by household (x)		
Value of gifted fish (y)		
Value of sold fish (z)		
Total (A)		
Production cost (direct)	**Total cost (USD)**	**Percentage of total**
Cost of pond preparation (C1)		
Cost of seeds and stocking (C2)		
Cost of feed (C3)		
Cost of other inputs (C4)		
Cost of post-stocking management (C5)		
Cost of hired laborers (C6)		
Any other costs _____		
Total direct cost (B1)		
Production cost (indirect)	**Total cost (USD)**	**Percentage of total**
Own farm products		
Time spent feeding (USD)		
Time spent fertilizing ponds (USD)		
Cost of laborers		
Fertilizer		
Meal cost during pond construction (USD)		
Total indirect cost (B2)		
Total profit =	Total value of products (A) - Total cost of production (B1+B2)	
Total profit (+ indirect cost) =		
Total profit (without indirect cost) =		

*Note: Total production value calculated based on total consumed/gifted/sold quantity * market price.*

Suggestions and comments from the facilitator and MALFF officers

Date	Name	Observation	Suggestions and comments

Suggestions and comments from other visitors

Date	Name	Organization and designation	Comments

www.worldfishcenter.org