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Better management practices for genetically improved farmed tilapia (GIFT) in Timor-Leste

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Better management practices for genetically improved farmed tilapia (GIFT) in Timor-Leste

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List of abbreviations

ABW	Average bodyweight
BMP	better management practices
C	carbon
DO	dissolved oxygen
DW	dry weight
FFS	farmers' field school
FISH	CGIAR Research Program on Fish Agri-Food Systems
GIFT	genetically improved farmed tilapia
GPS	Global Positioning System
IAAS	integrated agriculture-aquaculture systems
K	potassium
MFAT	Ministry of Foreign Affairs and Trade
N	nitrogen
NADS	National Aquaculture Development Strategy
P	phosphorous
PADTL	Partnership for Aquaculture Development in Timor-Leste
SMEs	small- and medium-sized enterprises
TSP	triple super phosphate

1. Introduction

Worldwide, the demand for fish continues to grow rapidly. Sustainable intensification and expansion of aquaculture and innovations in fish production systems will be needed to meet this increased demand. It is with this in mind that WorldFish's 2017–2022 strategy and the CGIAR Research Program on Fish-Agri-Food Systems (FISH) (2017–2022) have emphasized the need for doubling total food fish production by 2030, particularly in developing countries. In order to achieve sustainable aquaculture growth, however, developing scalable aquaculture technology packages and better management practices (BMPs) interventions are necessary to narrow the fish demand-supply gap in the future while maintaining a healthy ecosystem.

In Timor-Leste, aquaculture development has been identified 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, 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 tons by 2030 and contribute to reducing widespread malnutrition by increasing average annual per capita consumption of fish from 6.1 to 15.0 kg.

Nile tilapia (*Oreochromis niloticus*) is the world's second-most commercially cultured species, 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 following rotational breeding of GIFT cohorts and by producing and disseminating high-quality monosex fingerlings across the country.

Along with establishing sustainable seed production and dissemination systems, WorldFish, in partnership with MAF conducted on-farm testing and validation of sustainable GIFT farming technologies applying BMPs. These were carried out from 2016 to 2018 across three municipalities—Ermera, Baucau and Bobonaro—employing a farmers' field school (FFS) approach. This group-based participatory learning method allows farmers to analyze a problem and reach a solution suitable for their local context. Low-cost feeding and fertilization options based on locally available resources were devised, and with the adoption of these options the FFS participants successfully realized an average extrapolated fish productivity of 4.3±1.5 t/ha/cycle. Thus, it was successfully demonstrated that GIFT can make a notable contribution to improving the food and nutrition security and augmenting the household income of farmers.

Scaling successful GIFT farming technologies in a wider agro-ecological context is crucial for creating lasting impacts on the livelihoods of a large number of resource-poor households across Timor-Leste. Taking technical, socioeconomic and environmental aspects into account, this document provides BMP guidelines for scaling sustainable GIFT farming in Timor-Leste. It is available in both Tetum and English to ensure that all stakeholders involved in promoting tilapia aquaculture—from grassroots to the central level— can access and use developed technologies and practices in the country.

This manual is one of the outputs of the Partnership for Aquaculture Development in Timor-Leste (PADTL), a 5-year project (2014–2019) funded by the Ministry of Foreign Affairs and Trade (MFAT), New Zealand, and implemented jointly by WorldFish and Timor-Leste's National Directorate of Aquaculture, Ministry of Agriculture and Fisheries. Mr. Acacio Guterres, director general of fisheries, along with key NDA staff, has provided valuable input while preparing these BMP guidelines. On-farm testing and validation of GIFT farming technologies in Timor-Leste, which the guidelines in this document are based on, became possible because of the voluntary participation of all the FFS participants across Ermera, Baucau and Bobonaro.

Led by WorldFish, FISH is developing BMP guidelines at the global level and contextualizing BMP resources at the country level to support sustainable GIFT farming in WorldFish focal and scaling countries. This country-specific BMP manual, produced as part of this approach, aims to enhance the capacity of grow-out farmers and extension service providers in Timor-Leste to support scaling of 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 of 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 are 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 Timor-Leste 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 by volume globally.
- Nile tilapia is one of the most commercially cultured species in the world.
- Nile tilapia is a tropical fish, making it 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 allows farmers 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 accepts 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, developed by WorldFish through selective breeding, is a fast-growing, hardy and resilient strain of Nile tilapia.
- Timor-Leste already has a state-of-the-art GIFT hatchery. It was established in 2016 by the Ministry of Agriculture and Fisheries, with technical assistance from WorldFish and funding support from the New Zealand Aid Programme.
- The hatchery has maintained genetic quality by following rotational breeding of GIFT cohorts, and by producing and disseminating high-quality monosex fingerlings.
- Over 1000 farmers across Timor-Leste are currently farming GIFT. Demand for GIFT seed has continuously increased because of its quality on-farm performance.
- Farming monosex GIFT following BMPs allows Timorese fish farmers to sustainably increase the productivity and viability of aquaculture.

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

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

Key aspects for sustainable tilapia aquaculture in Timor-Leste

- **Aquaculture in suitable agro-ecologies**: Promote tilapia in agro-ecological pockets with potential for scaling and in harmony with other land and water users.

- **Farmers groups/clusters**: Organize farmers into groups/clusters at the Suco level to facilitate easy access to input (seed, feed), services (technology, extension, market) and knowledge sharing between farmers.

- **Production and marketing strategies**: Plan crop calendar and stocking, harvesting, and marketing strategies as per the need of groups/clusters.

- **Quality seed**: Use GIFT for better survival and growth.

- **Water quality and depth**: Maintain proper water depth (> 1 m) throughout the production cycle. Turbid water is not good for tilapia. The color of the water should be green, and plankton density should be adequate (Secchi disk depth 30–40 cm).

- **Fertilization and feeding**: Fertilize ponds using urea, triple super phosphate (TSP) and/or organic manure, and maintain green pond water to enhance in situ production of natural food for fish.

- **Cost-effective feeding**: Locally available ingredients like rice bran, leucaena leaf meal, cornmeal, taro leaf meal and cassava leaf meal are a few ingredients that can be used for on-farm feed preparation.

- **Strong farmers groups/clusters**: Strengthen farmers groups by linking them with market (local and distant markets) and input supply systems (seed, feed), and technical, extension and financial services.

Photo credit: Silvino Gomes/WorldFish

3. Organizing farmers in groups

- Organizing farmers in groups/clusters is an ideal approach for developing sustainable aquaculture at the level of small-scale/small- and medium-sized enterprises (SMEs) in Timor-Leste.
- Tilapia production groups/clusters should be formed at the Suco/Aldeias level in suitable agro-ecological zones.
- Accessing inputs (seed, feed) and services (extension, market) becomes convenient when farmers are organized into groups/clusters.
- Knowledge sharing and provision of technical support becomes more efficient.
- A farmers group should ideally consist of 15–30 members.
- The group members should possess at least one fishpond per household.
- Members of the group should meet at regular intervals (at least once a month) to share their experiences with respect to the growth and performance of fish, and also to discuss any problems and reach solutions.

4. GIFT farming planning

- Aim for two production cycles in a year (5–6 months per cycle).
- Tilapia is warm water fish. Optimum temperature range for growth and reproduction is 25°C–30°C.
- Semi-intensive pond culture of GIFT is the most common culture system for small-scale, poor farmers in Timor-Leste.
- Demand centers for fish should be identified, either for local consumers, local demand centers (schools, hospitals, military, and police barracks) or for retailers/supermarkets.
- Where appropriate, integrated agriculture-aquaculture systems (IAASs) can be promoted to reduce the economic risk of crop failure and increase resilience of farming households.
- Maintaining a crop calendar and sticking to it will ensure that stocking, production, harvesting and marketing of fish are done in a systematic way.

Photo credit: Silvino Gomes/WorldFish

5. Site selection

- Select the area with a favorable resource-base and social and economic context for fish farming.
- Ensure compliance with Timor-Leste environmental law, land and water use policy, as well as local cultural and social norms and regulations (e.g. *Tara Bandu*) before selecting a site.
- Construct the farm pond in a suitable site 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 flood/drought prone;
  - the area is accessible by road to buy inputs and sell products.

Clay/loamy soil

Sandy soil

6. Pond design and construction

- **Shape**: The shape of a pond can vary based on the land available. Square and rectangular shaped ponds are easy to build. Rectangular ponds are more practical to construct, feed and manage.
- **Size**: Pond size may vary widely from as small as 50 m^2 to 1 ha. From a management point of view, 200–1000 m^2 is an ideal pond size for Timor-Leste conditions.
- **Depth**: The water depth should be 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**: Dikes should be elevated at such a level that floodwater cannot enter the pond. Both inner and outer sides of dikes should be sloped between 1.5:1 m and 2:1 m, respectively.
- **Inlet, outlet and overflow**: A regular water supply, draining and overflow are all necessary for improved fish culture. The inlet and overflow pipes should be at least 20 cm above the water surface to prevent fish from escaping.

7. Pond preparation and management

7.1 Pond preparation

- Renovating an old pond:
    - Completely drain the water to get rid of predators and fish from previous crops in the pond.
    - Remove excess sludge/organic waste from the bottom and dry the pond for 1–2 weeks.
    - Renovate the dikes and cut the weeds and grass on the dikes.
    - Check the water for leaks from the dikes or around the inlet or outlet, and stop them by packing with good clay soil.
- Apply lime (preferably agricultural lime) to increase soil pH and kill harmful organisms.

Type of lime	Amount required (kg/100 m² pond)	
	New pond	Old pond
Limestone (Agricultural lime) $CaCO_3$	10.0	5.0
Quicklime CaO	5.5	2.75
Hydrated lime $Ca(OH)_2$	7.5	3.75

Table 1. Liming rate.

- Fill the pond with fresh water using filter nets in the inlet pipe.

7.2 Pond management

- Managing a pond involves a daily routine that may 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 surface of the water, erratic swimming, or decreased swimming activity.
    - Make sure the water depth is adequate and that the water color is green.
    - Ensure that net screens in the inlet and outlet are in place and not clogged or torn.
    - Cut the weeds and grass on the banks of the pond.
    - Protect fish from birds, frogs, snakes and other predators. Cover ponds with a nylon net to protect the fish from predators.
    - Do not allow animals (such as cattle, buffalo, pigs and goats) to graze on the banks 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 in 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 the dead fish.
    - If fish are gasping on the pond surface (particularly early in the morning), this indicates that the level of DO is low. Add fresh water and create a fountain to increase the DO level. Alternatively you can also increase DO in the pond by stirring the water with a bamboo pole or a tree branch.
    - If the pond is turning black and smells foul, drain it partially and add fresh water.

7.3 Pond fertilization

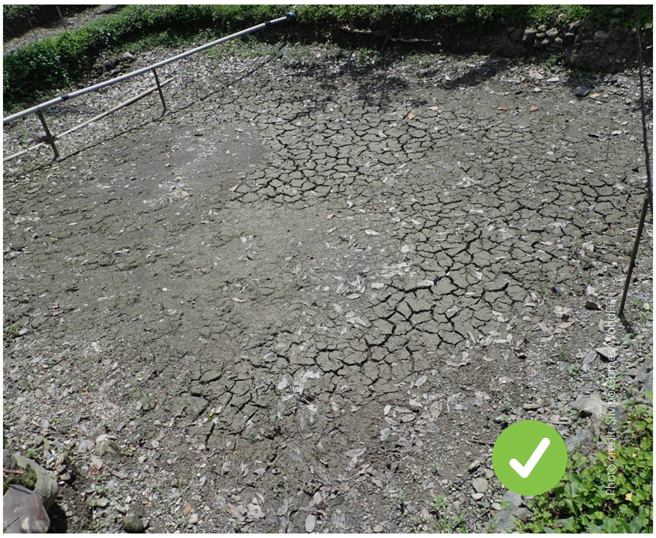
- Nile tilapia likes to feed on plankton. Fertilizers provide nutrients to stimulate the growth of phytoplankton.
- Nitrogen (N), phosphorous (P) and carbon (C) are the major inputs in pond fertilization. Potassium (K) is not considered a fertilizer element in a fishpond.
- Fertilize the pond with organic manure, inorganic fertilizers or a combination of both to enhance in situ production of natural food (plankton) (Table 2).

Pond fertilization rate per week for a 100 m² pond 610 g urea and 350 g TSP
Combination of organic and inorganic fertilizer for a 100 m² pond Chicken manure: 10 kg (DW)/kg Chemical fertilizer: Reduce by 50%

Table 2. Fertilization rates.

- Apply fertilizer and/or manure weekly at the rate of 28 kg N/ha/week and 7 kg P/ha/week (Table 2).
- Do not over fertilize. Adjust fertilization rate and frequency to maintain a light-green color in the pond (Secchi disk reading 30–40 cm).

- Dissolve chemical fertilizers in water before applying them into the pond. Place organic manure in one corner of the pond.
- Place a bamboo/wooden substrate in the pond to promote colonization of periphyton. Fish will easily browse periphyton colonized on the substrate.



Properly dried pond

Undried pond

Black soil removed

Black soil not removed

Adequate water depth

Shallow pond (inadequate water depth)

- Adjust the rate and frequency of fertilization based on plankton density in the pond.
- Maintain plankton density within a suitable range. The color of the water should be light green, and Secchi disk visibility should be 30 cm.
- Maintain a water depth of about 1–1.2 m in the pond by topping up the water to replenish water loss from evaporation and percolation.

Application of lime


No lime application


A pond with periphyton sticks

Turbid water


Manure application


Manure application

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

Small seed

Large and uniform size monosex fingerlings

Proper seed packaging

Transport during morning or evening

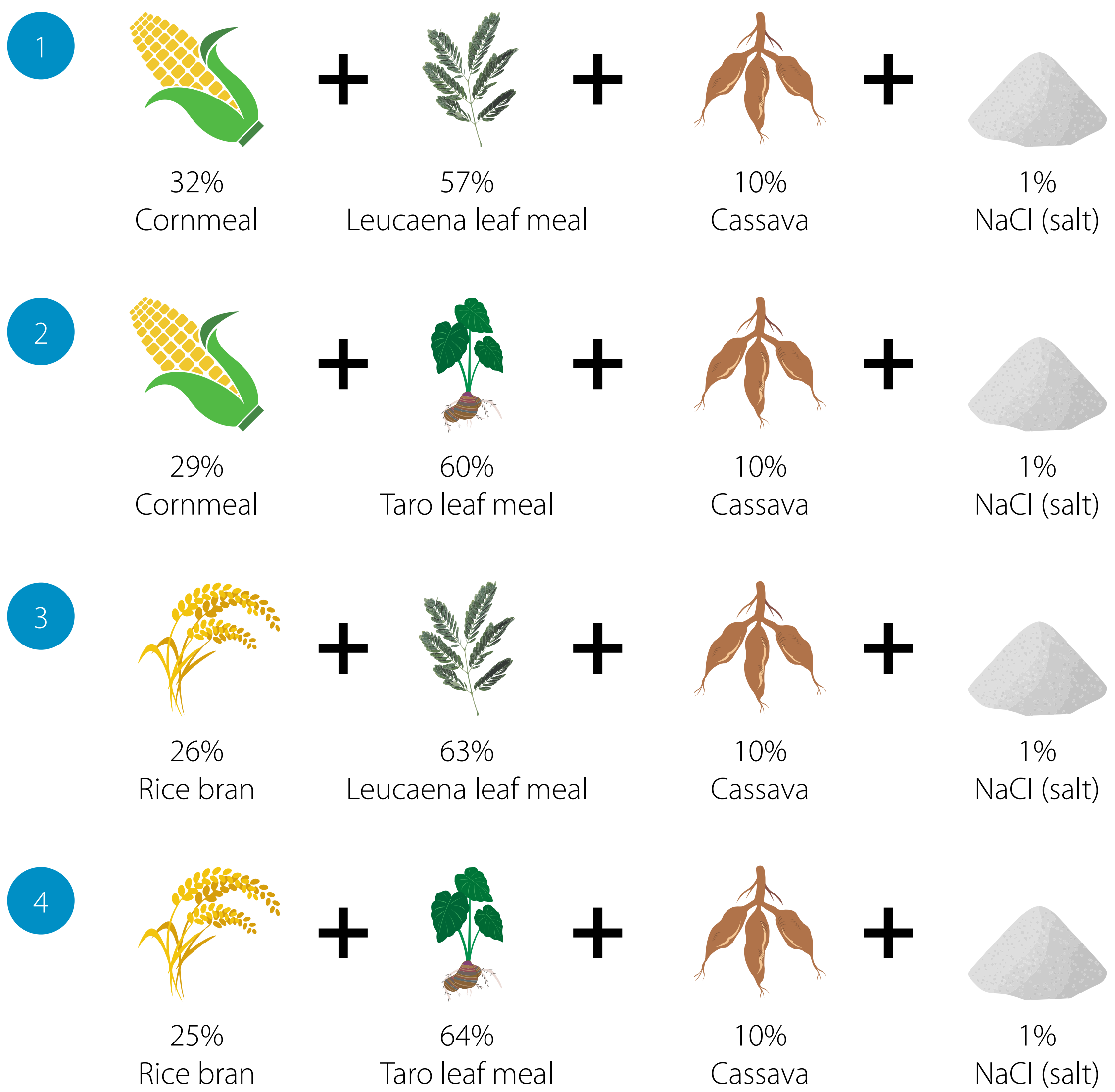
Releasing fingerlings into pond

Farmer receiving fingerlings

9. Feeding management

- In fertilized ponds, tilapia grow faster when provided with supplemental feed.
- Depending on cost and availability, tilapia can be fed with floating pellets, sinking pellets or farm-made feed based on locally available ingredients.
- Cornmeal, rice bran, leucaena leaf meal, taro leaf meal and cassava are plant-based ingredients that can be used for on-farm feed preparation.
- Pre-treatment is required for some of the ingredients before using them in the feed:
    - Leucaena leaf meal: soaked in water for 2 days and sun-dried
    - Taro leaf: leaves are sun-dried and ground finely.
- The most cost-effective options for tilapia production systems (small-scale/SMEs) are a combination of farm-made feed for feeding along with fertilizer for pond fertilization.
- Feed fish twice daily, at least 6 days per week, unless the DO is low. Feeding is normally performed manually or mechanically.
- Apply an adequate quantity of feed by following a feeding guide based on the bodyweight of the fish.
- Feed according to the total weight of fish in the pond, and increase the amount of feed as fish weight increases, based on sampling.
- Weigh the feed for the proper amount needed at each feeding time.

Major feed formation options based on locally available ingredients



- Feed fish in the same place and at the same a time.
- Use a feeding frame for floating feed and feeding tray for sinking feed to confine feed in a certain area and minimize waste.
- In large ponds, apply feed over a wide area of the pond and in many places. This ensures that many fish can feed at the same time without much competition.
- Feed fish slowly; do not dump feed all at once.
- Do not overfeed the fish. Too much uneaten food on 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 a few hours, 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 cloudy and the fish are coming to the surface gasping for air, give them less food.
- If using pellet feed, select the proper pellet 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 sunset.

Bodyweight (g)	**Daily feeding rate (% of bodyweight)**	**Number of feeding times per day**
1–5	6–10	4
5–25	5	3
25–150	3	2
150–250	2	2
250–500	1	2

Table 3. Guide for feeding tilapia at 24 ∘ C–30 ∘ C using formulated feed.

Using feeding tray to control feed loss

Farm-made feed balls

Farm-made feed pellets

Locally sourced feed ingredients

Applying feed into pond

10. Water quality monitoring and management

10.1 pH

- The pH of pond water should be between 7 and 9.
- Check water pH at regular intervals (where pH meter is available).
- If the pH is lower than 6, apply lime to increase it.
- If the pH is higher than 9, replace the water to reduce it.

10.2 Dissolved oxygen

- Maintaining an adequate DO level is crucial. DO concentration should be higher than 5 mg/L and not less than 2 mg/L in the early morning.
- If oxygen levels in the pond are low, the fish will come to pond 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 back into the pond water.
- Smallholder farmers without access to a pump can use a bamboo/wooden pole to stir the pond water and create a ripple effect to increase the level of DO. If necessary, exchange the water.

10.3 Water color and Secchi disk reading

- The color of the pond water should be light green.
- Transparency (Secchi disk depth) should be 30–40 cm.

DO meter

Secchi disk reading

Water quality monitoring kit

11. Fish growth and health management

11.1 Periodic fish sampling

- Collect a fish sample once every 2–4 weeks to estimate the growth rate and the total fish biomass in the pond, and also to calculate the daily feed ration.
- Use a method that does not disturb the pond bottom excessively. It is better to collect samples in the morning. Weigh the fish as soon as they are caught, then release them back into the pond.
- Calculate the average bodyweight (ABW) of the fish by dividing the weight of the sampled fish by the number of fish in the sample:

  ABW = Total weight of a random sample of fish (g)/Number of fish in sample.

- Estimate the total fish biomass in the pond based on the average weight of the sample of fish:

  Total biomass (kg) = ABW (g) x total number of fish stocked in the pond/1000.

- Estimate daily feeding rate based on feeding chart and total fish biomass in the pond.

11.2 Fish diseases

- Nile tilapia is hardier and more resistant to disease than other commonly cultured freshwater fish species, as long as the pond water is within the optimal temperature range (18°C–37°C),
- A disease outbreak usually occurs when fish have been exposed to stress, such as high water temperature, low DO levels, or overcrowding of fish in a pond for a longer period.

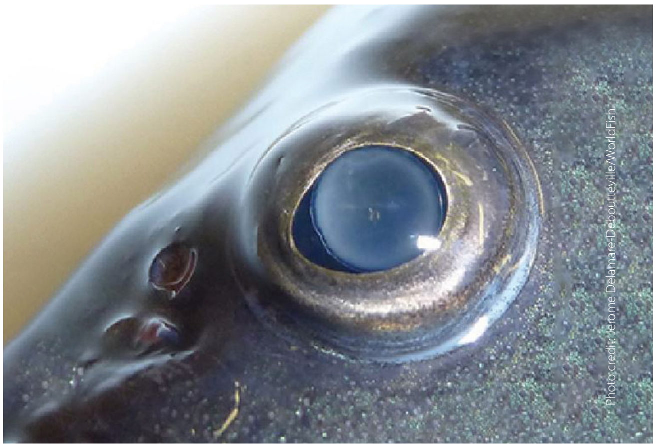
Common clinical signs of diseases and parasitic infections in tilapia

- Fish eat less or stop feeding
- 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 appear on the gills
- Reduced growth rate
- Physical weakness, bent bodies and fatigue in movement
- Fish swimming in circles, losing balance, floating upside down
- Reddish pigmentation around the anus or on the genital papilla
- Hemorrhages on eye and skin
- Cloudy and opaque eyes
- Swollen belly (dropsy condition)
- Swelling of internal organs such as liver, kidney, gall bladder and spleen
- Empty stomach or gut

Regular fish sampling

Growth check

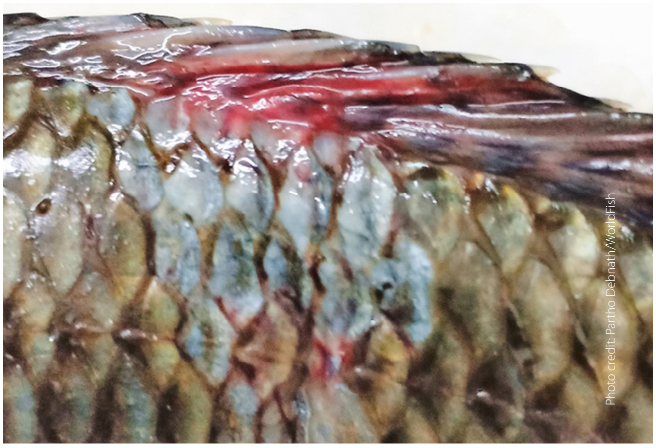
- There are a number of preventive measures farmers can use to reduce the risk of diseases and parasitic infection:
  - Stock pond with healthy, disease-free seed.
  - Disinfect all tools used in fish culture operations.
  - Avoid overcrowding.
  - Follow proper feeding, fertilization and water quality management practices.
  - Conduct routine screening for any sign of disease/stress.
  - Record all clinical signs, take pictures of clinical signs, and record of 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 responsible authorities and assist them to collect sick and moribund samples for laboratory testing.
  - Follow the suggestion of the responsible authority for disease management.



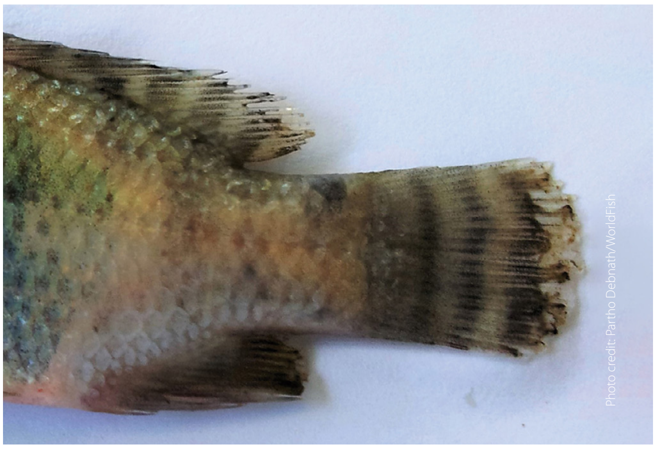
Eye opacification

Skin erosions hemorrhagic lesion

Abdominal distension/swelling



Scale protrusion/detachment



Open wounds

Fish gasping air at the surface

12. Harvesting and postharvest handling

12.1 Harvesting practice

- Harvest fish 5–6 months after stocking when they reach >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. Make sure neighboring farmers are informed about the harvest.
- Stop pond fertilization 2 weeks prior to harvesting.
- Do not feed the fish the day before the harvest to allow them to empty their guts. 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 for 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 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, carry out seining 3–4 times and then drain the pond completely.
- Complete the harvesting process within 1–3 hours.
- Collect harvested fish in a hapa installed in the pond for selling live fish.

Fish harvesting ceremony at Leohitu

Harvested fish in hapa for sale

12.2 Postharvest handling

- Handle fish in the morning or under shade, and use an aeration system or lots of flowing water.
- If 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 aeration system is not available, do not overcrowd fish in small containers. If fish are coming to the surface to gasp for air (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 fish, use scoop nets made of soft material to avoid bruising the fish. Seine nets should be made of fine mesh, as coarse mesh nets will trap the fish by their gills and cause injury.
- Handle fish gently; avoid dropping them on the ground or leaving them out of the water.
- When 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.
- Make sure good-quality ice is used (prepared with treated, potable water) during harvesting and packing.
- Pack fish with crushed ice in transport tubs (insulated boxes) at a 1:1 ratio for better preservation.
- Before stacking packed crates on top of one another, make sure the bottoms are clean. Always maintain cleanliness.

Harvested fish with crushed ice

Harvested fish without ice

13. 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.

- Improved marketing practices:
  - Organizing farmers into groups/clusters is the only way for small-scale farmers to become more efficient at marketing.
  - A farmers group can purchase quality farm inputs at cheaper prices (compared to individual prices) to reduce the cost of production.
  - Several local farmers groups can join together to market farmed tilapia for consistent supply and better prices.
  - Responsible and successful farmers groups are attractive to the banking and insurance sectors for extending credit and crop insurance. This will reduce the financial burden and risk on farmers.
  - Harvest only the quantity of fish that you expect to sell on the same day, and sell them as soon as possible. Plan to harvest fish on Friday, special occasions or festivals when people want to buy fish.
  - It is better to advertise the day of the harvest in advance so that people come prepared to buy the fish. Ensure that people know where the fish will be sold.
  - Organize a fish marketing campaign that attracts a large number of customers to buy your products.
  - In Timor-Leste, farmers' weekly markets are a great venue for selling fish to local consumers.

Live tilapia in tank in a restaurant in Dili

14. Record keeping

- Maintain a pond record book (one book per pond) for recording all activities, including routine ones (e.g. 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 the fish production system.
- Keep the following records in a logbook for each pond over a complete production cycle:
  - **Pond**: pond information/dimension, 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 type of on-farm inputs (e.g. rice bran, corn bran, etc.), amount of expenses, market price, feeding rate and total amount of feed used in 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), rate of mortality, 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 kg
  - **Labor**: total amount of labor used per cycle and total wages.

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Annex. Pond record book

Record year from _____ to _____

Farmer/group information

Farmer/group registration code (ID):	
Farmer/group leader name*:	
District:	
Sub-district:	
Suco:	
Aldeia:	
Project intervention:	Monosex GIFT technology
Date of enrollment of farmer/group to the project:	

Pond information (one record book per pond)

Pond identification number (ID):		
Pond GPS coordinates (latitude/longitude):		
Area of pond (m X m):		
Average depth of pond:	Highest: m	Lowest: m
Type of pond:	Earthen/Cemented	
Year of construction:		
Year last used for fish farming:		

* If this pond is operated by a group, list the group member names:

Pre-stocking information

Example activities: pond digging, removal of sludge, pond drying, liming, water filling, fertilization, etc.
Example inputs: labor, lime, organic manure/fertilizer, inorganic fertilizer, etc.

Date	**All activities done before GIFT seed stocking**	**Inputs used**	**Amount of used inputs** (kg/person day)	**Source** (On-farm/market)	**Cost for purchased item** (USD)

GIFT seed stocking information

Example water color: clear, light green, green, dark green, turbid, brown, dark brown.

Date	**Number of seeds** (n)	**Size** (cm)	**Source/ hatchery name**	**Purchase price** (USD)	**Mode of transport**	**Water color in the pond**	**Remarks**

Feeding practice information (daily/weekly basis)

Date	**Feed used**	**On-farm/ market**	**Feeding frequency per week**	**Quantity used per week** (kg/number)	**Expenses** (USD)		**Remarks**
					Direct cost	Indirect cost	

Other husbandry practice information (weekly basis)

Example inputs: labor, lime, organic manure/fertilizer, inorganic fertilizer, etc.

Date	**Input used**	**Source** (On-farm/market)	**Frequency per week**	**Quantity used per week** (kg/person day)	**Expenses** (USD)	**Remarks**

Water quality information (weekly basis)

Date	**Water color** (clear, light green, green, dark green, turbid, brown, dark brown)	**Secchi disk/hand reading** (cm)	**Remarks**

Health and growth monitoring information (bi-weekly basis)

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

Date	**Length** (cm)	**Weight** (g)	**Occurrence of mortality** (Yes/No)	**If yes, number of fish dead**	**Gross observations if any**

Harvesting, consumption and marketing information (for every harvest)

Date	**Quantity harvested** (number)	**Quantity harvested** (kg)	**Quantity consumed in household** (kg)	**Quantity gifted** (kg)	**Quantity sold** (kg)	**Market price per kg if sold** (USD)	**Total income** (USD)	**Did you observe any fingerlings as a result of spawning?** (Yes/No)
Total								

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

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

Production value	Total value (USD)
Value of consumed fish by household	
Value of gifted fish	
Value of sold fish	
Total (A)	

Production cost (direct)	Total cost (USD)
Cost of pond preparation	
Cost of seeds and stocking	
Cost of feeds	
Cost of other inputs	
Cost of post-stocking management	
Cost of hired laborers	
Any other costs ____________	
Any other costs ____________	
Any other costs ____________	
Any other costs ____________	
Total (B1)	

Production cost (indirect)	Total cost (USD)
Own farm products	
Time spent feeding	
Time spent fertilizing ponds	
Cost of laborers	
Fertilizer	
Meal cost during pond construction	
Total (B2)	

Total profit =	**Total value of products (A) - Total cost for production (B)**
Total profit (including indirect cost) =	**Total (A) - Total (B1+B2)**
=	
Total profit (without indirect cost) =	**Total (A) - Total (B1)**
=	

Facilitator's and MAF officers comments

Date	Name	Observation	Suggestion & comments

Visitors' comments

Date	Name	Organization & designation	Comments

RESEARCH PROGRAM ON Fish

Led by WorldFish

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Pursuing a research agenda through a network of multistakeholder partners, the CGIAR Research Program on Fish Agri-Food Systems (FISH) enhances the contributions of fisheries and aquaculture to reducing poverty and improving food security and nutrition. FISH is led by WorldFish, together with the ARC Centre of Excellence in Coral Reef Studies at James Cook University, Australia; the International Water Management Institute (IWMI); Natural Resources Institute (NRI) at the University of Greenwich, England and Wageningen University & Research (WUR), Netherlands. In regional contexts, the program partners closely with governments, NGOs, the private sector and research organizations to influence national, regional and global policy and development practice.

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