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Tilapia grow-out culture manual for smallholder farmers in Myanmar

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Tilapia grow-out culture manual for smallholder farmers in Myanmar

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List of abbreviations

ABW	average body weight
BCR	benefit-cost ratio
CDZ	Central Dry Zone
DOF	Department of Fisheries
DO	dissolved oxygen
FCR	feed conversion ratio
GIFT	Genetically Improved Farmed Tilapia
LIFT	Livelihoods and Food Security Fund
MFF	Myanmar Fisheries Federation
MYSAP	Myanmar Sustainable Aquaculture Program
NGO	nongovernmental organization
TSP	trisuperphosphate
SPAITS	Scaling Systems and Partnerships for Accelerating the Adoption of Improved Tilapia Strains by Small-Scale Fish Farmers

Executive summary

Aquaculture was initiated in Myanmar in the late 1950s with Java tilapia (*Oreochromis mossambica*), a short-period culture species for local farmers interested in pursuing aquaculture. However, because of the preferences of the Myanmar people, carp became the dominant species in aquaculture and is now widespread.

Recognizing the advantages of tilapia aquaculture in neighboring countries, Myanmar imported Nile tilapia (*O. niloticus*) and blue tilapia (*O. aureus*) from Israel in 1977. The expectation was to produce monosex progenies by crossing the two species to extend tilapia aquaculture. Later, hybrid tilapia such as red tilapia and rubyfish (*Tab-Tim*) from Thailand and Taiwan were also imported. However, a lack of farm management capacity for harvesting and controlling the propagation and progenies led to tilapia aquaculture being undeveloped in Myanmar.

In August 2016, with funding support from the Livelihoods and Food Security Fund (LIFT), WorldFish Myanmar and the Department of Fisheries (DOF) introduced 3000 seeds of Genetically Improved Farmed Tilapia (GIFT). The seeds were intensively cultured in the Hlawgar Fisheries Station in Yangon. The broods were then distributed to Mandalay Madaya (Nad Yae Kan) Fisheries Station and the Myanmar Fisheries Federation (MFF) hatchery in Shwebo. Tilapia hatcheries were built at these fisheries stations, funded by three projects that were implemented by WorldFish: MYCulture (funded by the LIFT), and the Myanmar Sustainable Aquaculture Program (MYSAP) and Inland projects (both funded by the German Agency for International Cooperation). The monosex seeds produced in the hatcheries were then distributed to local smallholder fish farmers and partner farmers of WorldFish projects.

Nowadays, smallholder fish farmers, mainly in the Ayeyarwady Delta, Central Dry Zone (CDZ) and the states of Kayah, Shan and Kachin, are interested to try their hand at grow-out GIFT farming. As such, thanks to the technical information provided by the field facilitators, this manual has been put together as a guide for smallholder farmers who wish to culture affordable tilapia. The contents of the manual include sections on pond preparation, fertilization, stocking, grow-out farming, feed processing, feeding regimen, monitoring during grow-out, preparedness for natural disasters, harvesting, marketing and recordkeeping. There is also a section on dealing with potential diseases and building the management capacity of farmers to enhance their knowledge.

Introduction

Tilapia has been described as the most important aquaculture species of the 21st century (Shelton 2002). The fish is grown in more than 100 countries around the world, and Nile tilapia, specifically, is the world's second-most commercially cultured species, after carps.

GIFT, which WorldFish developed through selective breeding, is a fast-growing, hardy and resilient strain of Nile tilapia. Java tilapia and common carps were introduced first into Myanmar aquaculture, followed by carps. Since carps were introduced, however, farmers have not been interested in farming tilapia because of a lack of management skills and knowledge on breeding and the selective (batch) harvest system. Initially, tilapia were farmed alongside carps. However, the result was offspring and stunted broods that competed with carps for space. This, in turn, inhibited the feeding and growth of carps—the main culture species in Myanmar and which fetches high market prices.

During the late 1970s, Nile tilapia and blue tilapia were introduced into Myanmar to produce a a hybrid strain by crossbreeding male blue tilapia and female Nile tilapia. However, weak support, inadequate resources, insufficient demonstrations and a lack of funding hindered the program. Despite this, Nile tilapia is still farmed throughout the country. The combination of tilapia's production potential, which requires low inputs in a short culture period, and high export potential brought about the introduction of hybrids red tilapia and rubyfish in the 1990s. Still, standard tilapia culture in small ponds and batch harvests continue to lag far behind the output of extensive carp culture. The 2- to 3-year culture period before harvest discourages farmers, and a lack of demonstrations, capacity buildings and promotions have not helped matters. Almost 80% of finfish aquaculture in Myanmar occurs in areas of the Ayeyarwady Delta, where carps are the main target species. Instead, tilapia are regarded as side products, at best, but usually seen as species that infest waters through water pumps and fish transfers.

Some private hatcheries produced mixed-sex seeds of Nile tilapia, which farmers could grow out in 6 months and harvest. However, government aquaculture development programs and capacity building had not included tilapia aquaculture and its management. Tilapia was no longer intentionally produced in government hatcheries, and so the DOF had stopped selling tilapia seed. Instead, tilapia only occurred naturally in carp ponds. As a result, seed quality for grow-out was varied, which translated into variations in both growth and production.

In 2016, in collaboration with the DOF, WorldFish Myanmar introduced GIFT into the Hlawgar Hatchery in Yangon Region and the Daedeye Hatchery in the Ayeyarwady Delta to improve tilapia aquaculture in the country. To this end, the DOF's Hlawgar Fishery Station was renovated to undertake and maintain the genetic quality of the GIFT through rotationally breeding among the cohorts. In 2017, two new satellite hatcheries in the CDZ, one that belongs to the DOF and the other to the MFF, which is a private sector institution, were established. Together, they began producing and disseminating quality monosex male fingerlings across the country, starting in 2018.

This manual has been processed mainly based on the findings from on-farm demonstration trials with the small-scale aquaculture development projects, led by WorldFish, as well as secondary sources. It aims to help develop GIFT farming and improve conventional tilapia farming all over the country.

1. Site selection

Selecting the right site is among the most important aspects of fish farming, as it determines the level productivity and profitability. The following are the main criteria for selecting a proper site:

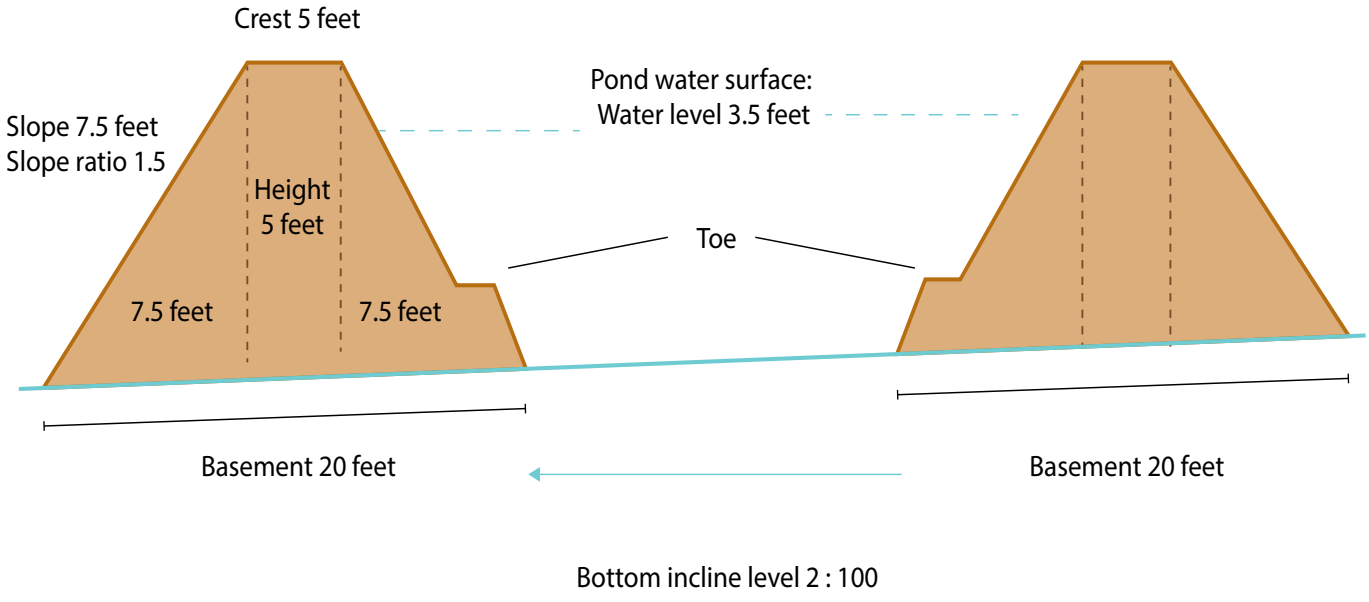
- **Soil type**: Avoid sandy, loamy and acidic soil. Clay soil is the best for constructing a pond.
- **Landscape**: Select an area that is wide enough to expand the pond in the future, and one that is near a water source. However, it is necessary to avoid potential contamination from industrial waste and chemical drainage. Select a site that is well exposed to sunlight and wind. Avoid the canopy of big trees.
- **Water sources**: Choose a site that has good water availability (river, creek, canal, rain-fed, well water, irrigated water), adequacy (6 months or year-round is the best) and quality (physico-chemically suitable for the target species to grow).
- **Assessments and communication**: Ensure there is a nearby road, waterway or passenger line so that products can be transported easily to markets. Input materials such as seed, feed, fertilizer and ice are also needed, as are provisions for those working at the site, including health, welfare and education.
- **Security**: Make sure that the selected site is safe and secure for laborers and personnel to work at, and is protected from poaching.

GIFT grow-put pond (0.17 acres) in Dedaye Township of the Ayeyarwady Delta, Myanmar.

2. Pond design

To set up an aquaculture farm, design and lay out the ponds, water source, inlet canal and drainage according to the landscape available. Generally, the layout plan of a typical fish farm has six main components: (1) nursery ponds for nursing fry to produce fingerlings, (2) rearing ponds for the fingerlings to grow to premature sizes, (3) grow-out ponds to culture premature fish to marketable sizes, (4) a reservoir pond to store reserve water to top up fishponds, (5) a supply canal to distribute water from the reservoir to the fishponds, and (6) a drainage canal to discharge water from the fishponds.

- **Structure**: A rectangular pond is recommended over that of a square or round-shaped pond because rectangular ponds make it easier to monitor feeding, to harvest the fish and to drain and clean the bottom.
- **Dike (bund)**: Build dikes according to the soil type, local amount of rainfall and any flooded adjacent areas. The structure of a dike is outlined in Figure 1.
- **Crest of the dike**: An important part of the dike is to ensure access between the ponds to monitor feeding, to harvest the fish, etc. Normally the crest should be at least 3 feet for small ponds and up to 15–20 feet for large ponds. Before building the dike, it is important to consider the soil quality, the height needed to avoid floods and the width of the crest, after which the layout of the design can be done.
- **Slope of the dike**: The strength of the dike to resist flooding and waves is important. This depends on the soil type. Table 1 shows how to calculate the slope according to the soil type, the required width of the crest and the intended use of the land.
- **Toe**: This runs from the base of the dike to the inner slope in order to reduce soil erosion from the slope.



Source: Soe 2010.

Figure 1. Typical structure of a fishpond.

- **Pond bottom**: Ensure the bottom of the pond is as even as possible. This will help determine, exactly or approximately, the water depth, which in turn will help with calculating the volume of water in the pond. The bottom of the pond must have an incline no greater than 2% to the drainage or outlet gate so that the pond can be drained at harvest using just gravity.

- **Water depth**: About 1.5 m is regarded as the ideal water depth. Set up a measuring pole in the pond before filling it with water so that you can easily see the water level.

- **Feeding platform**: Build a bamboo or wooden platform/bridge about 3 m in length.

- **Pond size**: For tilapia culture, ponds can range from 0.05 acres to 1–2.5 acres. Even smaller ponds of 0.03 acres perform well at growing monosex GIFT.

- **Water inlet, outlet (overflow) system**: Ensure that the pond has a water inlet, outlet or overflow system to exchange water, protect it from flooding and prevent dike erosion when flooding occurs. Maintain the water at the required level. Excess water will drain away through the overflow pipe. Thick PVC pipes 3-4 inches in diameter are suitable for both the inlet and outlet. Install the inlet at the higher end, connected to the water supply canal. Install the outlet (overflow) at the lower end

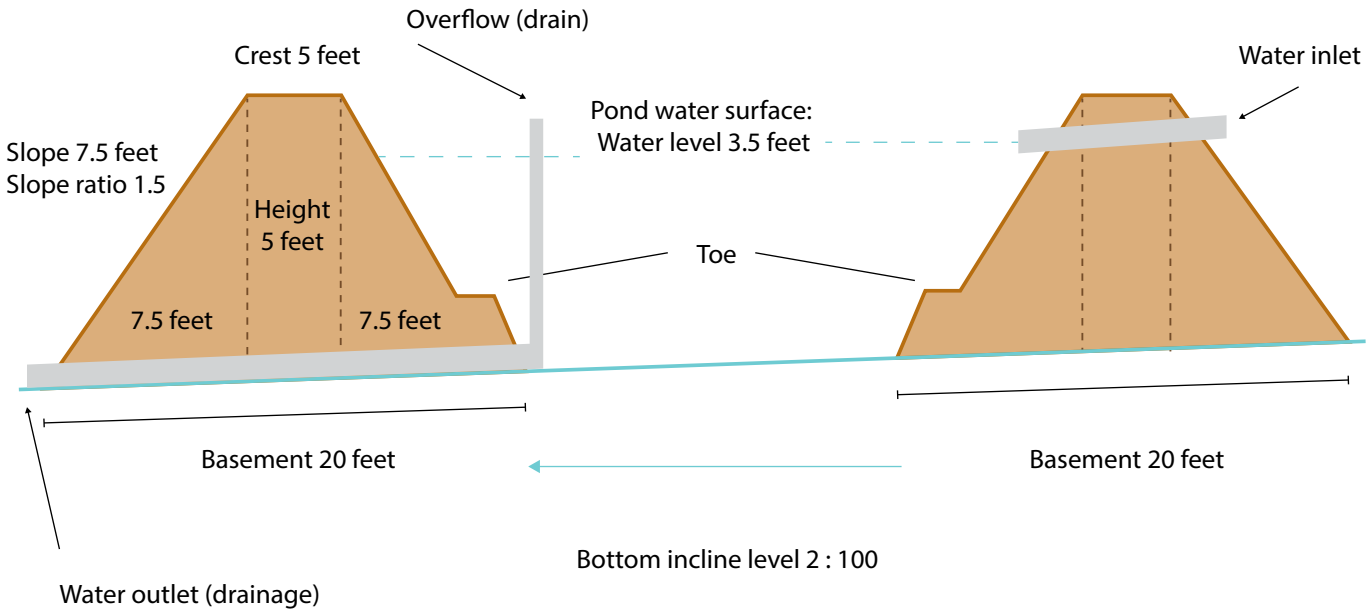
Soil type	Height (feet)	Slope recommend	Crest width (feet)	Outer slope base (feet)	Inner slope base (feet)	Total base of the dike (feet)	Total width of land surface to be used for dikes (4 sides) (square feet)
Clay soil	1	1:1	10	10	10	30	120 ft x total length of the pond
Clay soil	5	1:1.5	5	7.5	7.5	20	80 ft x total length of the pond
Sandy soil	5	1:2	5	10	10	25	100 ft x total length of the pond

Table 1. Land shared for building dikes in fishpond construction.

Newly established rectangular pond.

of the pond, connected to the drain canal. It is necessary to attach a fine mesh screen to the entry of the inlet pipe. For outlet/overflow pipes, attach a fine mesh screen to the water entry end to prevent cultured fish from escaping (Figure 4).

- **Fencing**: Build a fence around the area of the farmsite to prevent poaching, as well as encroachment in the vicinity of the fish farm. Fence the pond all along the embankments to prevent the fish from escaping into natural water and, in reverse, to prevent wild (natural) fish from entering the culture ponds.



Source: Soe KM 2010.

Figure 2. Water inlet/outlet and overflow system setup design.

Renovating an old pond into a GIFT grow-out pond in Kyaiklat Township of the Ayeyarwady Delta: drying the pond, measuring the water depth with a pillar/pole, installing a feeding platform.

3. Pond preparation

3.1. Renovating old ponds and filling with water

If the culture pond is old, do the following requirements and repairs before filling the pond with water:

- Drain the pond to get rid of carnivorous fish, as more than likely there are wild fish, such as snakehead, seabass and walking catfish, and mixed-sex tilapia eggs or fry from previous crops.
- Use a fine mesh net to remove these fish.
- Remove excess sludge/organic waste from the bottom and dry the pond for 1–2 weeks until the soil becomes cracked, if possible, to eliminate harmful gases such as hydrogen sulphide and ammonia trapped underneath the bottom.
- Repair the pond dikes as necessary to make them strong, and cut the weeds and grass on the dikes.
- Applying lime during pond preparation reduces water turbidity, increases the pH level, improves the effectiveness of fertilizer and destroys parasites, microorganisms and bacteria.

If it is not possible to drain all the water from the pond and dry it completely, remove aquatic plants and/or weeds, such as water hyacinth, water mimosa, water lily and water cress, within the pond by hand and/or sickle. Otherwise, these plants will compete for the dissolved oxygen (DO) in the pond water as well as nutrients that are essential for primary production (plankton), which will become natural food for the cultured fish. Leave a small portion of aquatic plants in the pond, as tilapia can feed on the periphyton on the stalks of those plants and/or on the plants directly.

One week after applying the lime, fill the pond with fresh water up to the desired level using filter nets over the inlet pipe.

Type	Dosage (kg/acre)	
	Old pond	New pond
Limestone (Agricultural lime) $CaCO_3$	400	200
Quicklime (burnt lime) CaO	200	100
Hydrated lime $Ca(OH)_2$	300	150

Table 2. Application rate of lime in fish culture ponds.

- Check for burrows or holes, from where water could leak out the dike slope or around the inlet or outlet, and fill them with soil.
- Apply lime (quicklime, agricultural lime, hydrated lime or dolomite) to increase the soil pH and kill harmful organisms. Quicklime (burnt lime) is good in fish culture and is easily available and affordable across Myanmar. It is also recommended to use dolomite [$CaMg(CO_3)_2$] during the culture period, if available.

3.2. Pond fertilization

In general, smallholder farmers have been practicing a semi-intensive culture system that relies on natural food, but only to certain extent as they also use supplementary feed. As fish prefer more natural food to supplementary feed in their food intake, having an abundance of natural feed such as phytoplankton, zooplankton and microphytes in fishponds can reduce the amount of supplementary feed needed for fish farming. Fertilizers provide nutrients to stimulate the growth of phytoplankton and improve the productivity of natural food, such as algae, small insects and worms.

Although there are several types of fertilizers, agriculture fertilizers generally fall into two categories, and these are also used in aquaculture to develop natural food in fishponds practicing a semi-intensive culture system:

1. Organic fertilizer: animal manure such as cow dung, chicken drops, and compost

2. Inorganic fertilizer: chemically synthesized, such as triple super phosphate (TSP), urea (nitrogen-enriched compound), and a mixture of phosphate, nitrogen and potassium.

3.2.1. Fertilizer doses, preparation and application

The amount of fertilizer to apply depends on the fertility of the pond. Table 3 represents a standard chart for fertilization.

Fertilizer	Amount per acre
Compost	400–600 kg (during pond preparation)
Urea	15–20 kg
TSP	7.5–10 kg

Table 3. Standard rate of fertilization for a fishpond with a normal primary production level.

3.2.2. Fertilizer preparation and application

- Soak TSP overnight. Between 10:00 and 11:00 the next morning, mix urea into water along with the soaked TSP, and then broadcast evenly on the surface of the pond so that plankton can grow thoroughly on the surface.

- Do not apply fertilizer directly without dissolving in water first, especially TSP as it takes time to dissolve in water. If TSP is applied directly into the water, it will descend to the bottom and enhance the growth of weeds/plants there that can disturb the space for cultured fish and result in high oxygen demand for the pond water at night.

- Apply fertilizer weekly or biweekly during the culture period to maintain natural food.

- Do not over fertilize. Adjust the fertilization rate and frequency to maintain a light-green color in the pond. (To measure water transparency, use a Secchi disk: 30–40 cm is good level for the growth of natural food in a pond.)

GIFT seeds (first introduced from the WorldFish Jitra Fisheries Station in Penang, Malaysia) being nursed at the DOF Hlawgar Fisheries Station in Yangon.

- Do not apply fertilizer if the pond water is turbid.
- Do not apply fertilizer on very hot days if the water is shallow.
- Do not apply fertilizer 2–3 days before and after netting, especially before harvesting the fish.
- Watch carefully to ensure all fertilizer has been well diluted/dissolved before application.

Locally available inorganic fertilizers (urea, TSP, potash) from left to right.

Tips to consider for fertilizer application

- Do not apply fertilizer if the sky is cloudy or if it is raining, as it is less reactive without sunlight.
- Stop applying fertilizer if the water turns dark green, as light green is the desired color.
- Apply a lower dose of fertilizer during winter (either half or less than half of the dose used in summer).

A field staff monitoring pond water fertilization using a Secchi disk in Kyaiklat Township of the Ayeyarwady Delta.

4. Water suitability testing

If the water in an old pond cannot be drained completely and/or properly prepared, the pond water might not be suitable for fish farming. As such, prior to stocking fingerlings, do a water suitability test by releasing 8–10 fish into a hapa installed in the same pond or into a pot or bucket outside the pond by taking water from the culture pond and observing it for 4–5 hours. If all the fingerlings survive and remain healthy, then the pond is ready to be stocked with fish.

5. Controlling and checking for predators

Non-targeted or undesirable fish in ponds compete for food and shelter with cultured fish. Wild fish and carnivores, such as snakehead, seabass and walking catfish, are all potential disease carriers. To eliminate these predators, use angling fishing with live bait (small frogs, fish, shrimp, earthworms) or use specific chemicals, such as rotenone, to kill these potential predators.

6. Stocking fingerlings

6.1. Size of fingerlings to stock

- Acquiring good-quality GIFT fingerlings of the same age and uniform size for stocking is important.
- On average, 3–5 g fingerlings are suitable for stocking.
- Use all-male (monosex) tilapia for fast growth rate, and make sure the seeds are all of uniform size.
- Nurse small fingerlings with proper feeding in a hapa placed in the pond. This will reduce the mortality of the fingerlings.
- Release the fingerlings from the hapa when they reach an average size of 3–5 g.
- If the average size is larger than 3–5 g, then stock them directly into the culture pond.

6.2. Stocking density

- The stocking density of GIFT fingerlings depends on the type and duration of the cultural system.
- Stock fingerlings at 3–5/m^2 (12,000–20,000 per acre) for a semi-intensive monoculture system. The stocking density can be higher in an intensive monospecies culture system.
- In a mixed culture system (polyculture) with carp, the density of tilapia can be either the same or less than that of a tilapia monoculture. Determining the proper proportion depends on the species to mix. For example, if tilapia is the main species, then the proportion of tilapia stocked should be higher than that of composite species, and vice-versa.

6.3. Transporting and acclimatizing fingerlings

Transport fingerlings in the morning or late evening when the temperature is low, especially during the hot season. During the rainy season, fingerlings can be transported anytime during the day if there is rain. Otherwise, it is important to avoid high temperatures between late morning and afternoon to reduce stress on the fish.

Whatever the hatchery or nursery farm, and wherever the source of fingerlings, whether close or far, using a sealed type of packaging and shipping is preferable, as it helps minimize potential loss or damage.

Means of transportation	Container	Volume of water (L)	Sizes of fry (g) / fingerlings (inches)	Packaging fish/bag	Transportation time (hours)
Road: car or motorbike Waterway: motorized boat	Oxygen inflated sealed polyethylene bag (1/3 clean water and 2/3 oxygen)	20–25	3-4 inches	200–250 fingerlings	6–8
		2.5–3	0.3–0.4 g	250–300 fry	6–8
		5	3–5 g	100 fingerlings	6–8

Table 4. Packing fry/fingerlings for transportation.

6.4. Acclimatizing fingerlings with pond water and stocking

- Upon arrival at the farmsite, unload the bags of fish and let them float them in the pond water under the shade for 10–15 minutes.
- Spray or flush the bags with pond water while they are floating.
- Open the bags and gradually splash in pond water to acclimatize the fish to the temperature of the water, as well as other physico-chemical factors.
- Dip the bags into the pond water to let the fish swim out of the bags and into the pond.

Shipping GIFT fingerlings at the Shwebo MFF Hatchery.

Distributing GIFT fingerlings to a small-scale farmer from Shwebo.

7. Feeding

Feed management is one of the most important practices in grow-out culture. In aquaculture, the feed cost accounts for 60%–70% of total production, while other operating costs, such as seed, fertilizer, lime, labor, fuel, etc., account for the remaining 30%–40%.

7.1. Calculating the amount of feed

If farmers follow good feeding practices, the economic return could be high for any kind of grow-out system, including aquaculture.

7.1.1. Feed conversion ratio (FCR)

This is the number resulting from dividing the total amount of feed given to fish by total fish production. In other words, the FCR is the amount of feed used to produce one unit weight (i.e kilogram or viss) of fish.

(FCR = total amount of feed given / total fish volume produced)

For example, an FCR of 2 means the amount of feed used to get 1 kg of fish is 2 kg. Therefore, the lower the FCR, the greater the profit in fish farming, so it is important for farmers to pay attention to feed management.

According to recommendations and field trial findings, the FCR should not exceed 1.5 for a farm using commercial floating pellet feed and 2.5 for the farms using local ingredients. This will ensure that an aquaculture business can make a profit, assuming feed and fish prices remain relatively stable. Therefore, proper feed management needs to be practiced throughout the culture cycle.

The recommended feeding rate based on field trials of semi-intensive GIFT monosex culture for 6 months in Myanmar's Ayeyarwady Delta is shown in Table 5.

7.1.2. Calculation for daily feeding

- Biomass in the pond (kg): ABW of fish x number of fish in the pond (= A)
- Assumed feeding rate (%): e.g. 5% of biomass
- Amount of feed required: A x 5%

Notes:
Measure the ABW of the fish once a month.

- Sample the fish in the pond and estimate the number of fish to determine the survival rate.
- Calculate the biomass (in weight) for a month: ABW x number of live fish.

Days of culture	Average body weight (ABW) of fish (g)		Daily feeding rate (%) by the standing biomass	Daily feeding frequency
	Feeding with commercial pellets	Feeding with ingredients (rice bran, broken rice, oil seed cake or a mix of all)		
1–30	5–25	5–20	3–4	3
31–60	25–100	20–65	2-3	2
61–90	100–250	65–100	2	2
91–120	250–350	100–200	2	2
121–150	350–500	200–300	1.5	2
151–180	500–700	300–400	1.5	2

Table 5. Recommended amount for daily feeding.

- Calculate the daily amount of feed for a month by the desired feeding rate.
- While sampling fish monthly to determine growth and survival, be on the lookout for any abnormalities in the fish.

7.1.3. Monthly sampling for fish growth

7.1.1. Materials

- Buckets to hold live fish.
- Cast nets to capture fish alive.
- A top-loading digital balance or a spring balance for weighing the sampled fish.
- A measuring board, measuring tape or a printed measuring vinyl chart.
- Record books and pencils.
- At least three people to do the sampling.

7.1.2. Sampling procedure

- Sample the fish from the dike and under shade in a sampling pond.
- Capture fish for sampling using a cast net from different parts of the pond area.
- Keep the fish in buckets that are large enough to hold the samples. Use more buckets if necessary.
- Measure the total length by centimeters and record the result. Weigh the fish and record the result (g).
- Release the fish back into the pond immediately after measuring.

Notes:

- Sample the fish during the cool part of the day and avoid bright sunshine. Complete the sampling process in a short period of time.
- Clean and dry the sampling equipment (cast net, weighing scale, bucket, scoop net, glove, etc.) properly.
- Handle the fish as gently as possible.
- Avoid using gillnets to capture the fish for sampling.
- Make sure the water in the bucket has about 15–20 ppt of saline (add about 20 g of NaCl (kitchen salt) for a liter of water) to disinfect the sampled fish in case some fish were injured or damaged during the sampling process.

7.2. Feed management

Begin feeding from the second day of stocking. In fertilized ponds, tilapia grow faster when supplementary feed is given. In addition to natural food, feed tilapia with commercial floating pellets, sinking pellets or farm-made feed. Farm-made feed can be made/formulated using locally available

A GIFT farmer feeding his fish from a feeding platform made of bamboo.

ingredients such as rice bran, broken rice, dried fish/shrimp powder, oil cake, cassava powder, wheat flour, maize flour, etc. Use a formulated, standardized, certified floating pellet or feed/farm-made pellet feed with a minimum protein content of 20%. Commercial floating pellet feed can be purchased from a feed agent or directly from the factory.

7.3. Farm-made feed

For an operator to produce 50 kg of feed per day, the following materials are needed: a small feed extruder (meat mincer), grinder/pulverizer, and a diesel engine with about 10 hp.

Notes:

- Ensure all machines are properly secured to their frames.
- They must be able for one efficient person to produce 50 kg of feed daily.
- Practice feed production in groups or individuals.
- Two or more raw ingredients can be combined manually.

7.3.1. Farm-made feed-making process (mechanical)

- Collect and weigh the ingredients according to the ratio listed in Table 6.
- Grind or pound the raw materials (dried fish, peanut cake or sunflower cake) with a grinder to get a fine powder. Ground peanut cake or dried fish powder can also be used.
- Sieve all powdered ingredients (rice bran, dried fish and oil seed cake) with a fine mesh to get a homogeneous fine powder to enhance the binding capacity of the pellets.
- Mix the ground powders with wheat flour, cassava powder, salt and water, and then mix thoroughly until it becomes pasty and adhesive.
- Use the extruder (mincer) to transform the pasty mixture into pellets.
- Collect the extruded pellets (which will still have moisture) into either a plastic or aluminum bucket.
- Dry the fresh pellets under sunlight for 2 days or more, depending on the temperature.
- Once dried, keep the pellets in waterproof bags, and store them in a cool, dry place.

Pellets produced by an extruder will sink in water and take 30–45 minutes to dissolve. Depending on the composition of the binding ingredients, such as cassava or tapioca powder, the water stability of the pellets will vary. The longer they remain stable in the water the better the feed quality should be. However, they should not take longer than 2.5 hours to dissolve. Otherwise, the texture of the pellets will be too hard for the fish to digest, and the nutrition of the pellets starts to decline after 2 hours in water (Keri et al. 2013).

Ingredients	Protein content (%)		Composition of ingredients (g)		Protein content (%)
			Formula 1	Formula 2	
Polished rice	12	12	400	400	4.8
Dried fish	50	50	320	320	16
Peanut cake / sunflower cake	42	35	90	110	3.8
Cassava	14	14	100	100	1.4
Flour	16	16	80	80	1.2
Salt			10	10	-
Total			1000	1000	27.2

Table 6. Two feed formulas for 1 kg of farm-made pelleted feed with 27% crude protein.

Some locally available ingredients.

Rice bran

Dried fish powder

Peanut cake

Dried shrimp powder

7.3.1. Farm-made feed-making process (manual)

- Include three or more types of raw ingredients, such as rice bran, dried fish powder, some kind of oil seed cake (sunflower or peanut), cassava and wheat flour.
- Mix all the ingredients with water and then sieve them with a 1 mm fine mesh screen to get the feed to crumble. Dry the crumbles (small pieces of pellets) under the sun for at least 1 day, as necessary, and then store them in waterproof bags.

7.3.2. Storage

- Store pelleted feed in a proper storeroom or warehouse with good ventilation to control the moisture.
- To avoid infection from mold and fungus, stack the feed bags on a raised wooden platform so that they do not touch the floor or walls.
- Use the feed within 3 months from the date of production following a first-in first-out procedure. The quicker feed is used, the better. The risk of a fungus infection is greater in the rainy season because of the higher humidity.

7.3.3. Feed management

Feeding location

- Feed the fish at the same time and the same place so that the fish get accustomed to the feeding site.
- Making sounds at feeding time so that the fish become accustomed to the feeding time.
- Demarcate the feeding area with bamboo or PVC frames in the pond.

Feeding time

- On sunny days, the level of DO in a fishpond will rise, so it is acceptable to provide more feed. However, if the temperature of the pond water reaches 28°C–32°C, split the daily feeding into two times. Exercise caution when feeding, as higher water temperatures result in lower rates of water quality.
- When the weather is misty, cloudy or rainy, the DO level in the pond will drop, so the fish do not need to be fed more than usual.
- When there is no wind or when there is a thunder shower, the fish will lose their appetite. During these times, decrease the amount of feed or stop feeding the fish entirely, especially if a sudden change in the weather is expected.

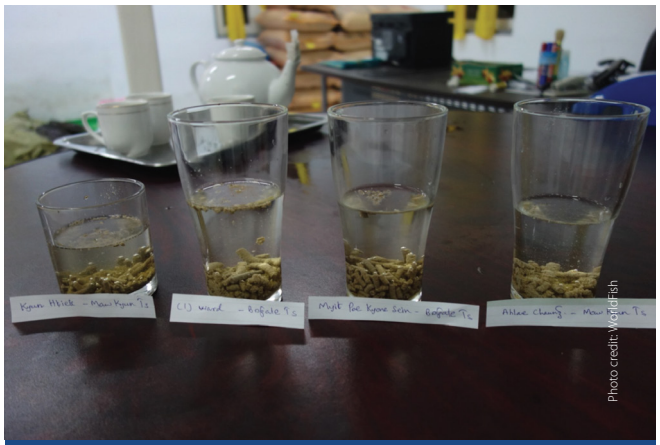
Testing the solubility of farm-made sinking pellet feed made from various small machines in the Ayeyarwady Delta.

8. Feeding and water quality

- **If the pond water turns brown or dark green**: Provide additional feed and use fertilizer moderately, as necessary.
- **If the pond water turns a thick dark green or black**: This means that the pond is overfertilized with excess nutrients from the dumping of decomposed material and debris at the bottom. The scum of dead algae will be floating on the surface, and the fish will swim weakly on the surface and gasp for air. When this occurs, feed the fish less or stop feeding them entirely. Immediately, either top-up or exchange half of the pond water.

9. Feeding and fish health

- Observe the condition of the fish on a regular basis. Check the feeding site an hour after feeding every morning and evening. If the feed has been eaten, then increase the amount of feed; if the feed has still not been eaten 2–3 hours after feeding, then reduce the amount of feed accordingly.
- Whether using commercial pelleted feed or homemade feed, always check the activities and behavior of the fish. The health and growth of fish and productivity all depend upon the quality of feed used.
- Provide the fish with the pelleted feed that matches the moth size of the fish. In other words, it is necessary to adjust the sizes of commercial pelleted feed to match the fish grown in the pond.



Processing farm-made feed using a small extruder (meat mincer) in Bogalay Township of the Ayeyarwady Delta.

A GIFT grow-out demonstration farm, located in Kyaiklat Township of the Ayeyarwady Delta, with the feeding area demarcated with bamboo poles.

10. Monitoring fishponds

- **Visual examination (feeding at 08:00–09:00)**: Check for drops in the water level and for seepages and leaks. Use a Secchi disk to determine the water color. Look for signs of wild fish having entered the pond or fish escaping from the pond, as well as for possible occurrences of poaching. Measure the pH of the water again in the late afternoon around 15:30.

- **Physico-chemical parameters**: Use an apparatus to measure the DO, pH and water temperature at 08:00–09:00.

- **Biology**: Observe the fish to make sure they are swimming actively and eating the feed, and to detect any occurrence of abnormalities, such as dead fish or fish swimming slowly on the surface and gasping for air. Look also for signs of wild fish having entered the pond, poaching and theft.

- **Rainy season**: Take precautions for the potential of flooding. It is advisable to erect a fence with a strong screen around the perimeter of the pond to prevent fish from escaping out of the pond or from wild fish entering from the outside. It is important to check that the drain (overflow) system has a screen attached to remove any debris and material that could block the drain (overflow).

- **Weather**: Try to stay updated on weather conditions. Be ready and prepared for extraordinary and extreme weather conditions, such as drought, floods, storms and heavy rains, as well as cool spills. In summer, use reserve water to top up the fishpond. In the rainy season, use fence nets and bamboo frames to prevent fish from escaping out of the pond if there is flooding.

10.1. Common problems and possible solutions

If the pond water becomes oxygen deficient for any reason, immediately stop feeding and fertilizing and try the following solutions to solve the problem:

- Use a pitcher or bamboo, or any other means, to stir up the pond water. The waves will recirculate the pond water (pump the water from one end, and shower into the pond).

- Apply Oxyflo/Oxylife at about 500–700 g per acre.

- Top up the pond water with clean, oxygen-rich water from outside the pond.

If a red layer appears on the surface of the water, try any of the following solutions:

- Drag a rope made from rice straw or banana leaves along the surface of the water to remove the red layer.

- Apply 10–15 kg of urea per acre. Do this two or three times every 10–12 days.

- Apply 10 kg of potassium aluminium sulfate (potash alum) per acre.

If a dark green bloom appears in the pond water, try any of the following solutions:

- Apply 100 kg of gypsum per acre.

- Put 1–1.2 kg of copper sulfate in a small packet and then tie it to a small piece of bamboo.

If the pond water becomes turbid, try any of the following solutions:

- Apply 50 kg of burnt lime per acre.

- Apply 100–150 kg of gypsum per acre.

- Apply 100–150 kg of dry rice straw per acre.

- Apply 25 kg of potash alum per acre.

11. Water quality parameters

Tilapia are hardy fish and can tolerate a wide range of physical and chemical conditions, such as high temperatures, low DO levels and high water pH. Tilapia species generally adapt well to extreme and severe environments. However, it is necessary to create a healthy pond environment to maximize tilapia production.

- Temperature: 24˚C–30˚C (measure with a thermometer).
- DO: 5–7.5 mg/L (measure with a DO meter).
- pH: 6.5–8.5 (measure with litmus paper or a test kit).
- Transparency: 30–40 cm (measure with a Secchi disk or the flat palm of your hand). This indicates the status of natural food in the pond.
- Water color: Pond water ranges from clear, to light green, dark green, brownish-green and even near black. Color is assessed visually, and gives an indication of the amount of natural feed in the pond.

12. Disease control

Disease control is one of the most important aspects of fish pond culture, as it can determine the success or failure of aquaculture. In Myanmar, common clinical signs resulting from parasitic infections are usually seen early in the culture season and most frequently during the rainy season, as well as during the winter season, when the water temperature is lower (18°C–25°C).

Some parasitic clinical signs may occur in tilapia ponds during the hot season when the combined effect of increased temperatures, lower water levels and poor water quality, including low DO, stress the fish. The skin and gills of tilapia may become red, and secondary bacterial infections can occur. If not treated in time, this can result in fish mortality.

Diseases usually occur for one of three reasons: (1) stocking infected fish seed (fingerlings) from a hatchery, (2) injuries that occur during transportation, and (3) fish having been exposed to stress, such as high temperatures, low DO levels and overcrowding in a pond for a long period.

12.1. Common diseases in tilapia

The following are the clinical signs to look for in diseased tilapia:

- decreased appetite or no appetite at all
- white spots on the body
- pale gill lamella
- difficulty breathing
- swimming slowly
- cotton or wool white fungi on the body
- weight loss
- physically weak, bent bodies, fatigue
- swimming erratically
- cloudy and opaque eye
- sunken eye
- swollen belly
- swelling of internal organs such as the liver, kidney, spleen and gall bladder
- tail and fin rot
- reddish pigmentation around the anus or on the genital papilla.

Figure 3. Common clinical signs in tilapia.

12.2. Preventive measures

In aquaculture, it is important to apply preventive measures during the entire cycle: pre-stocking, stocking and post-stocking.

12.2.1. Pre-stocking and stocking

- Prepare and clean the pond thoroughly and maintain good water quality.
- Before stocking, dip the fingerlings in a potassium permanganate solution (20 mg/L) for 15–30 minutes, or dip the fry in a 2%–4% sodium chloride solution (20–40 g of salt/L) for 5–10 minutes.
- Dip the fry in a copper sulphate solution (8 mg/L) for 20–30 minutes.
- Use a dipping bath with a formalin solution (80 mg/L) for 1 hour.
- When it is cold, disinfect the pond with quicklime (15–30 g/m^2) before stocking.
- Handle the fish carefully during all phases of aquaculture management, including harvesting and transporting, to avoid fish injuries.

12.2.2. Post-stocking preventive measures

- Maintain good water quality through proper pond fertilization and feed management. Regularly check DO, pH, temperature and transparency and check fish growth and health. Take action as needed through

liming, adjusting the amount of feed fed, refilling and/or lowering the water level, and exchanging or agitating the pond water to increase the DO level.

12.3. Treatments

- If possible, replace the water with fresh water from outside the pond or farm.
- Dip the infected fish in a 1%–3% sodium chloride (NaCl) solution for 15 minutes.
- Broadcast potassium permanganate (3 mg/L) evenly across the whole pond area.
- Add a mixture (0.7 mg/L) of copper sulphate and ferrous sulphate, at a ratio of 5:2, evenly across the whole pond area.
- Mix a salt solution (400 mg/L) and sodium bicarbonate (baking soda) (400 mg/L) and spread evenly over the pond.

Fish farmers may find it difficult to apply disinfection materials at the recommended dose. One example is a 3 mg/L potassium permanganate solution. Since 3 mg is too small to weigh with a scale, multiply the water volume 10–20 times and the amount of $KMnO_4$ accordingly (i.e. 3 mg/L is the same as 30 mg/10 L or 60 mg/20 L).

12.4. Calculating doses

The volume of the pond can be calculated depending on the shape of the pond as follows:

- Water volume of a rectangular pond (m^3) = length (m) × width (m) × mean water depth (m)
- Water volume of a round pond (m^3) = 3.14 × r2 × mean water depth (m)
- The mean water depth is the average of the depth measured at several different areas in the pond.

The dose for spreading a chemical throughout the whole pond (mg) = pond water volume (m^3) × drug concentration (mg/L) × 1000

The dose for a dipping bath (mg) = volume of water used (m^3) × drug concentration (mg/L) × 1000.

13. Harvesting

13.1. Partial or selected harvesting

- Depending on the market demand and price suitability, farmers can conduct partial harvests.
- It is important that farmers keep updated on price trends and when prices tend to be seasonally high and low at both local markets and at markets farther away.
- Begin partial harvesting once the fish reach marketable size. This usually occurs 3–4 months after stocking, but may be sooner, depending on the market size that is in demand. At local markets, tilapia is increasingly being sold to barbecue shops and restaurants.
- Partial harvesting can be done two to three times in a production cycle or as many times as farmers want to.
- Repeated netting can, however, stress the fish and cause the pond to become turbid. Rather than harvesting frequently, harvest a lot of the fish at a time and hold some in a hapa within the fish pond to sell later.
- To avoid damaging the fish, use scoop nets made of soft net material, to gently catch the fish as needed from the hapa.

A farmer and his wife doing a partial harvest in Dedaye Township in the Ayeyarwady Delta.

13.2. Complete harvesting

- Complete harvesting can be done 5–6 months after stocking, as tilapia can reach 300–700 g depending on the growth rate resulting from the culture system, feed management and feeding strategy.

- Stop feeding the fish 1–2 days prior to the harvest to allow them to empty their stomachs. This will improve the water quality, survival and condition of the fish during handling.

- If the water level is high at harvest time, drain some of the water from the pond so that the fish can be seined in a way that minimizes stress.

- Harvest the fish early in the morning or late in the afternoon when the water temperature is lower. This will reduce stress on the fish while they are being seined and harvested.

- Prepare all equipment in advance: air stones and blowers (if selling live fish), clean water, holding tanks, hapas, hammocks, buckets, quality ice, seine nets, scoop nets, gloves, etc.

- To harvest all the fish in the pond effectively, set up relatively heavy lead weights or iron chains on the foot rope of the seine net. The height of the seine net (from top to bottom) and the net width should be appropriate for the pond size that is being harvested.

- If fish have to be sold at the farmgate, coordinate in advance with buyers so that they arrive on time and there are no delays loading the fish onto vehicles and/or onto boats. Any delays will cause the fish to lose their freshness, so buyers will want to negotiate lower prices.

- Hold harvested fish in a hapa installed in the pond ready so that they can be sold later.

GIFT harvest, F4L project farm, Madaya Township.

14. Marketing

Marketing is crucial for fish farming, as the price difference between times of fish scarcity and peak supply times can be more than double. Selling fish at peak prices can significantly increase farmers' profit margins.

Market demand for tilapia is strong year- round in the CDZ and upland Myanmar, which are fish deficit areas. There is less market demand for tilapia in lower Myanmar where carp species sourced from farms or natural water bodies are the preferred species.

Typically, the supply of wild fish is greatest in the monsoon season, while the peak supply of cultured fish is in the dry season (February, March, April). Tilapia are popular not only with households, but also with restaurants and side-street shops, which buy tilapia year-round for barbecuing, steaming and smoking.

Farmers should find as many potential buyers as possible, whether they are fish traders, wholesalers or retailers, restaurants, barbecue shops, or brokers, etc. It is better to connect with regular buyers for every harvest. Smallholder farmers should investigate and determine the local demand before harvesting, and they should also take into consideration the potential sales volumes of other farmers. In this way, farmers can identify other potential marketing places, such as central fish markets in cities, where they can sell their product with less competition. This will enable them to access a wider market and to get a better price.

Monosex GIFT from a grow-out pond in Dedaye of the Ayeyarwady Delta.

15. Natural disasters and extreme weather events

The monsoon seasons in Myanmar are when cyclones are most likely to occur, and with them the risk of flooding is greater. Coastal and inland low-lying areas have always been flood prone, but with climate change extreme weather events including drought, cyclones and flooding are more frequent countrywide. Nevertheless, by thorough preparation and by following disaster risk reduction measures it is possible to reduce both the risks and the potential economic losses.

15.1. Precautionary measures before natural disasters

- Listen to weather forecasts from various sources, including the Department of Hydrology and Meteorology disseminated through different media channels, including radio, TV and social media networks like Facebook. Stay alert for updates.
- If a natural disaster such as a cyclone is forecast, try to determine in advance if your fishpond is located within an area where heavy rainfall is likely to occur.
- Before any extreme weather event, if needed reinforce and raise the height of pond dikes to reduce the risk of fish escaping from the pond. If possible, fence the dike perimeter with blue nylon netting. This will help keep fish within the pond even if some water overflows.
- Before extreme weather events, lower the water level in the pond appropriately, as heavy rains will cause the water level to rise. Lowering the water at the right time can effectively prevent tilapia from escaping when the water level rises during rainfall events.
- To mitigate any potential loss of fish, selectively harvest and sell the biggest fish. If feasible consider doing a complete pond harvest.
- Make sure the feed storage shelter is strong and secure to prevent the feed from getting wet and damaged during sudden flooding. If possible raise the feed higher off the ground.
- Discuss and get feedback and suggestions from other local farmers who have had experience in preparing for natural disasters in this area, and take appropriate actions to respond to the disaster risk.
- To mitigate potential fish loss, prepare holding hapas and accessories in case the fish need to be moved temporarily and held in another pond that is at less risk of flooding.

15.2. Recovering fish production after a natural disaster

- After a disaster, inspect the farm to confirm what impact there may have been, and make efforts to recover production.
- Remove any tree branches and leaves immediately from the pond. Repair any damage to the pond, particularly the pond dikes, clean away any debris and remove and bury any dead fish in a pit away from the pond to avoid environmental contamination or disease. Repair any damage to the pond so that production can be resumed as soon as possible.
- Clean the inlet/outlet points and remove any predatory and non-cultured fish that may have entered the pond during any flooding.
- For ponds that are not damaged, the primary task is to control the reproduction of pathogens. Apply disinfectants, such as quicklime, at the right time to reduce turbidity and improve the water quality.
- If necessary, disinfect the fish with chemicals to prevent secondary diseases, such as skin ulcers and fungal infections caused by abrasion on the fish.
- For disinfected ponds, ensure proper DO levels are maintained. If it is convenient, replace part of the pond water with fresh water, and add fertilizer to the pond to stimulate natural food production, which will enhance fish growth.
- Discuss and get opinions from farmers in your peer group who have dealt with similar natural disasters before, and take action to respond to the disaster risk.
- If needed, restock with an appropriate number, and size of GIFT fingerlings.

16. Recordkeeping

Keep basic records, whether daily, biweekly or monthly, so that the data and information collected become a reliable reference that can be used to assess the impact of management practice changes and used to analyze profit and loss, expenses, benefit-cost ratio (BCR), and the FCR. In addition, it is important to practice, experience and learn about water quality management, growth rate, survival rate, feed management, fish yield, production and disease control mechanisms. Finally, smallholder farmers should adopt and adapt these practices through their own tilapia fish farming experience to ensure a successful business. The template forms below can be used by farmers to keep better records.

Number of ponds	
Type of pond (old or new)	
Area of pond (length x width) (m^2)	
Average pond water depth (m)	
Number of fingerlings stocked	
Average weight (g) of fingerlings stocked	
Total weight (kg) of fingerlings stocked	
Stocking density per m^2	
Stocking date (month day, year)	
Source of fingerlings	private hatchery, nursery or DOF hatchery
Survival rate (%)	
Total production (kg)	
Culture period (months)	

Table 7. General pond information.

Date	pH	Temperature (˚C)	Transparency (cm)	Water color	DO (mg/L)

Table 8. Weekly water quality management.

Date	Quantity of fertilizer (kg)		Quantity of lime (kg)	
	Organic	Chemical	Quicklime (CaO)	Agricultural lime ($CaCO_3$)

Table 9. Biweekly fertilizer and lime application.

Date	Type of feed	Size (mm)	Protein (%)	Date of manufacture	Quantity (kg)	Feeding frequency per day
	Commercial floating pellet					
	Commercial sinking pellet					
	Farm-made sinking pellet					
	Rice bran					
	Broken rice					
	Peanut cake					
	Sunflower cake					
	Dried fish powder					
	Dried shrimp by-product					
	Other (specify)					

Table 10. Daily feed application data.

Days of culture	Average weight (g)	Number of fish	Biomass (kg)	Percentage of biomass	Total feed given (kg)	FCR	Remarks

Table 11. Monthly FCR calculation.

Date	Clinical sign	Response	Chemicals applied	Dose	Person responsible	Remarks

Table 12. Disease-related issues during culture period.

Date	Number stocked	Number of mortalities	Number harvested	Amount harvested (kg)	Amount gifted (kg)	Amount consumed (kg)	Amount sold (kg)	Remarks
Total								

Table 13. Total production and disaggregated data.

Description	Cost (MMK)	Cost (USD)	Remarks
Pond renovation			
Seed			
Feed			
Fertilizer			
Lime			
Fuel			
Transportation			
Hired labor			
Pond rental cost (if not own fishpond)			
Cost of cost			
Buying/borrowing fishnets			
Other costs (specify)			
Miscellaneous			
Total			

Table 14. Operating cost for one production crop.

Total revenue (USD) = total harvest volume (kg) * unit price/kg (USD)

Gross margin = total revenue - total operating cost

BCR = total gross income / total operating cost

Conclusion

In Myanmar, polyculture of mixed Chinese and Indian carp species is the main fish culture practiced in the country today. While the production of tilapia in comparison with mixed carp species is still low, there is increasing demand for tilapia for both household consumption and street stalls and restaurants. Exclusive monosex monoculture of tilapia, in particular, still needs further development and support in the aquaculture sector of Myanmar.

The WorldFish-led GIFT intervention in Myanmar featured a breeding program, seed production program, seed distribution approach and grow-out farming for smallholder farmers in partnership with local nongovernmental organizations (NGOs), international NGOs and fisheries institutions like the MFF and the DOF under the Ministry of Agriculture, Irrigation and Livestock. The activities conducted have included upgrading, renovating and equipping existing public and private hatcheries, implementing biosecurity protocols for GIFT hatcheries, and providing technical support. The purpose is to oversee GIFT breeding and seed production, distribute GIFT seed to smallholder farmers through income and nutrition-oriented projects like MYCulture and MYSAP (Inland), develop a dissemination strategy for GIFT seed, assess performance, and establish a new mini hatchery through the SPAITS project. Project beneficiaries such as small-scale farmers were provided GIFT seed produced by the DOF as well as private hatcheries supported by WorldFish projects. In addition to seed provision, knowledge was shared and GIFT grow-out culture disseminated through GIFT grow-out culture training for farmers.

Results and findings from the above development projects, including SPAITS, indicate that GIFT performed better than non-GIFT tilapia in various geographic locations, including upland regions like the Shan State, the Ayeyarwady Delta and the CDZ of Myanmar. The results were confirmed from a number of demonstration ponds and grow-out ponds operated by smallholder farmers and project beneficiaries during the 2019, 2021 and 2022 culture cycles as well as from baseline and endline surveys on GIFT performance conducted in 2019 and 2022, respectively.

This manual was developed based on primary data from farm trials, demonstration pond farmers and grow-out farms, as well as secondary data such as briefs, manuals and guides, on tilapia culture from different regions and countries of the world. As the manual is a living document, the content is a 'work in progress" that will be modified as new data is collected. It will serve as a helpful handbook for extension service providers and small-scale farmers who want to scale their tilapia farming from subsistence-scale production up to a successful business.

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Annex 1. Measurements, units and conversions

Weight

1 kg = 1000 g

1 kg = 62.5 tical

1.6 kg = 1 viss

16 g = 1 tical

160 g = 1 tical

1000 kg = 1 metric ton

Volume, volume/weight

1 gallon = 4.43 L

1 ft^3 = 7.5 gallon

1 L = 1000 ml (cc)

1 L = 1 kg

Area and length

1 decimal = 436 ft^2 = 40.48 m^2

100 decimal = 1 acre = 0.405 ha = 43,560 ft^2

1 ha = 2.47 acre

1 m = 3.28 ft

1 m^2 = 10.76 ft^2

2.5 cm = 1 inch

12 inches = 1 ft

3 ft = 1 yard

1000 m = 1 km

1 km = 0.6 miles

About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving aquatic food systems, including fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world.

The WorldFish headquarters is in Penang, Malaysia, with regional offices across Africa, Asia and the Pacific. The organization is a member of CGIAR, the world's largest research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security and improving natural resources.

For more information, please visit www.worldfishcenter.org