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# Better management practices manual for smallholders farming tilapia in pond-based systems in Zambia

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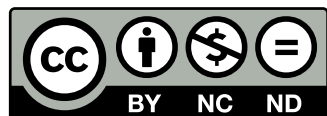
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Project



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# Summary

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Tilapia is one of the most popular fish species for farming and is second in terms of volume after carps. WorldFish has been working for decades on fish genetic improvement and dissemination activities across Asia and Africa. Building on this knowledge, the WorldFish Strategy (2017–2022) and CGIAR Research Program on Fish Agri-Food Systems (FISH) (2017–2022) are providing a combination of support to accelerate fish breeding, and improvement programs and increasing the impact of dissemination of improved fish breeds. Part of the approach is also to produce resources for better management practices (BMPs) to support sustainable farming of tilapia. This training manual for smallholders in Zambia growing tilapia in pond-based systems is one of the products developed under this approach. It is an output of the Aquaculture Technical Vocational and Entrepreneurship Training for Improved Private and Smallholder Skills (AQ TEVET) project.



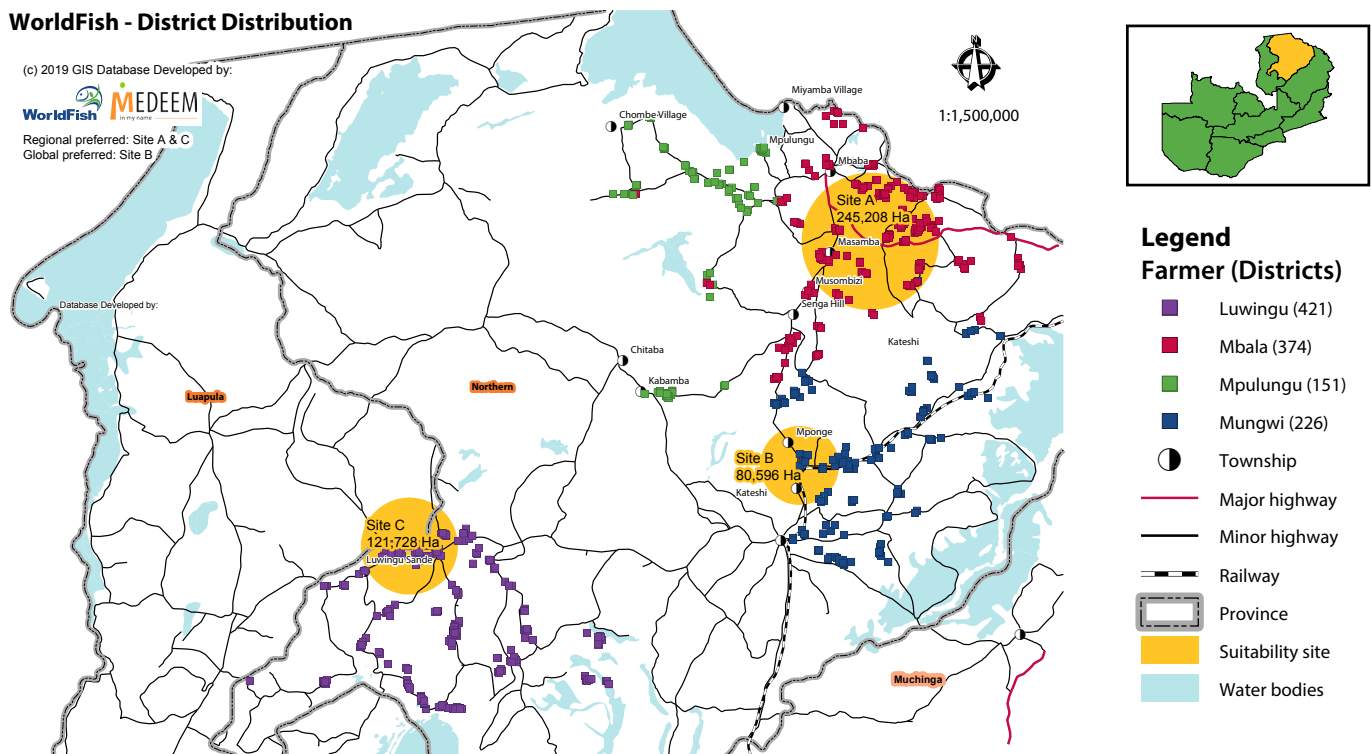
# Introduction

The AQ TEVET project aims to enhance the aquaculture extension services offered by the private sector operating within the aquaculture value chain, including smallholder fish farmers. One of the objectives is to develop the capacities of commercial actors along the aquaculture supply chain to deliver sustainable and profitable pro-poor, gender- and youth-responsive market services to the smallholder sector, including the provision of inputs and technologies, output marketing opportunities and extension, vocational training and technology transfer. This manual is one of the outputs that will serve the private sector to deliver training and extension services to smallholders and will contribute to harmonizing training throughout the country. The goal of these training and extension activities is to improve productivity and profitability of tilapia farms run by smallholders.

## Aquaculture industry in Zambia

Zambia has sufficient natural water resources to support aquaculture activities. In the recent years the aquaculture sector has responded positively to the large fish deficit caused by reduced yields from capture fisheries and rapid population growth. The annual production from aquaculture increased significantly from 5000 t in 2005 to about 30,000 t in 2016 (Namonje-Kapembwa and Samboko 2017), placing Zambia sixth in Africa for the production of farmed fish (Genschick et al. 2017). This growth was mainly achieved by medium and large commercial cage farms on lakes Kariba and Tanganyika (Genschick et al. 2017). Small-scale farms mainly produce for home consumption and some sales at farm gates or local markets.

The profits earned by smallholders are low, and there has been a noticeable decline in the production and productivity over the past years (Kaminski et al. 2017; Genschick et al. 2017). The economic viability of a fish farming enterprise is not a reason for smallholders to venture into fish farming in Zambia. They are more likely to adopt aquaculture activities based on the capacities of extension officers or development agencies to impart knowledge on how to farm fish (Mudenda 2009).



**Figure 1.** Distribution of smallholder farmers in Luwingu, Mbala, Mpulungu and Mungwi Districts of the Northern Province.

The majority of smallholders in Northern Province own fewer than five ponds, with an average area of about 200 m<sup>2</sup> for each pond, and close to a quarter of the farmers are inactive. The production per farm is very small. Half of the farmers produce 10 kg or less per production cycle and only 10% of farmers produce over 60 kg per cycle. The main factors constraining the development of aquaculture are access to feeds, lack of training, access to and quality of seed, insufficient extension services and limited capital.

According to fish traders, smallholders provide an inconsistent and limited supply and low quality of fish. Linkages between smallholders and the private sector can be improved to facilitate the organization of smallholders. Improved access to inputs will increase productivity for smallholders, and improved market access will reduce losses and allows smallholders to produce more fish (Kaminski et al. 2017).

The aquaculture value chain in Zambia is made up almost entirely by tilapia (Genschink et al. 2017). In Zambia, different species are farmed, with *Oreochromis niloticus* (Nile bream) being the main species, followed by *Oreochromis andersonni* (three-spotted), *Oreochromis macrochir* (green-headed bream), *Coptodon rendalli* (red-breasted bream) and *Oreochromis tanganiicae* (Tanganyika bream). This last species is produced in areas around Lake Tanganyika, where the species is indigenous. Tilapia is a fast-growing and robust fish with a high demand in the local market. The species tolerate a wide range of environmental conditions and can therefore be grown throughout the country.

### **Environmental and social impacts**

Compared with larger farms, smallholders often have a higher environmental impact per metric ton of production due to lower yields associated with the management of the farm (Kruijssen et al. 2018). By improving their management practices, smallholders can increase their yield and reduce negative impacts. The highest impact comes from feed production (agriculture activities for ingredients). To a lesser extent, water use and pollution of water are also affecting ecosystem quality. In the future, climate change may impact the hydrology of the main water bodies in the country (Kruijssen et al. 2018) Therefore, climate resiliency should be strengthened for the sector, especially for those operating in areas with a flood risk.

Zambia currently has a high rate of youth unemployment. The average age of farmers is 46 and only 24% of the farmers are under 35 years of age. There are also noticeable disparities between men and women in the labor force (CSO 2015). Gender inequality in rural areas of Zambia stems from social and cultural norms that restrict women's access to land and other natural resources. The fish farming population in Northern Province is dominated by men (81%). During pond construction, mostly male members of the household are involved. For pond preparation and maintenance, men are still dominating, but in many households these tasks are shared between men and women. Women are particularly active in farmers associations and cooperatives and as leaders.

Another objective of the AQ TEVET project is to increase the participation of women and youths in fish farming. All stakeholders, including the private sector, should encourage more women and youth to enter the fish farming economy. Involving women and youths in training programs can empower these groups by creating awareness about opportunities in fish farming.

### **Better management practices**

In order to increase social benefits, improve farm profitability and reduce negative environmental impacts, smallholders should implement BMPs. BMPs refer to a set of standardized management guidelines that are developed based on existing practices and associated risks. New innovations are also routinely incorporated into BMPs to facilitate continuous improvement in farming practices. The adoption of BMPs is important to comply with legislative obligations, use resources sustainably, reduce risk of disease and attain food quality standards. BMPs may also improve the perceptions of aquaculture and profitability.

## About this manual

This training manual on BMPs was developed to assist the private sector (feed companies, hatcheries, fish traders, etc.) to provide effective training programs to smallholders in Zambia. It targets extension service providers to facilitate improved interaction with the smallholders. The manual can also be used for training of trainers. The BMPs focus on tilapia culture in pond-based systems and is tailored to the local conditions and needs of smallholders in Zambia.

The training manual consists of five modules; (i) farm preparation, (ii) farm operation, (iii) postharvest management, (iv) business and (v) training. The first four modules cover the different topics (sections) that are essential to run a successful fish farm. The last module is solely included for the trainer and contains guidelines for the trainer to organize and facilitate an effective training course. The BMP training will only be effective if it is combined with other extension services such as provision of quality commercial feed, high quality seed and assistance with market access.



For each section, background information is included followed by a set of BMPs with notes for trainers. It also includes a trainer guide that aims to aid the trainer with discussion topics, questions, exercises and practical activities. It is a tool for the trainer to assist smallholders to increase their awareness on the importance of management practices, improve their knowledge on the different topics and learn new skills that will help them improve their farm performance.

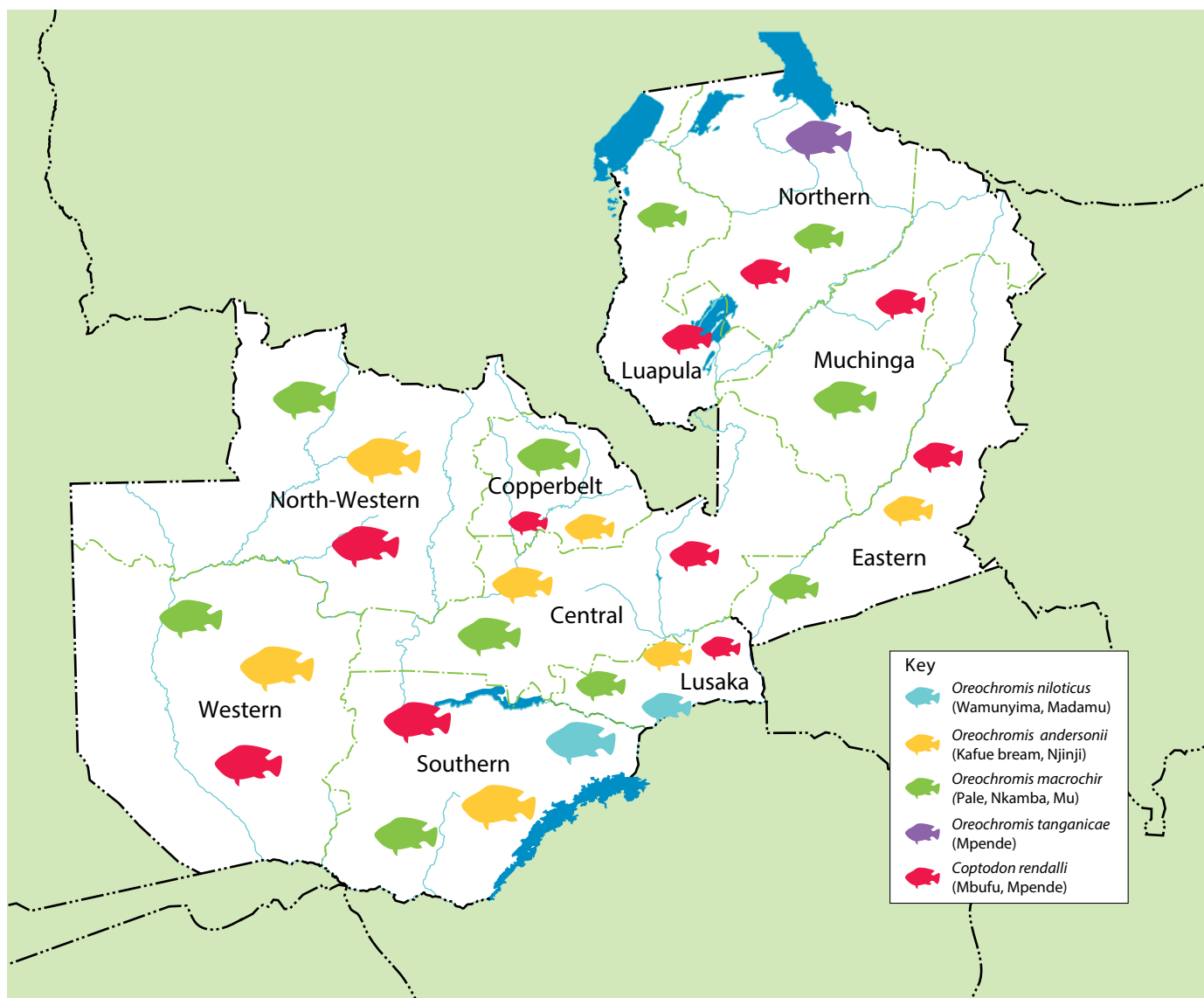


## Species selection

Tilapias grown in Zambia are predominantly characterized based on the differences in their reproduction and feeding habits. Species which evolved as substrate spawners and guard their eggs are in the genus *Coptodon* (formerly *Tilapia*). Those which orally rear their eggs are grouped into a new genus, *Oreochromis*. However, the common name “tilapia” is used for convenience to describe all species in both genera.

## Distribution of tilapia species in Zambia

Tilapia species are native in Zambia. Different regions of the country have specific local tilapia species, some of which have been developed for use in aquaculture. It is important to protect the genetic integrity of native species so that diversity in the natural world is not lost.



**Figure 2.** Presence of natural or established tilapia species in Zambia.



## Main characteristics of tilapia species cultured in Zambia

Species	Red-breasted bream <i>C. rendalli</i>	Nile bream <i>O. niloticus</i>	Three-spotted bream <i>O. andersonii</i>	Green-headed bream <i>O. macrochir</i>	Tanganyika bream <i>O. tanganicae</i>
Origin	Indigenous	Exotic	Indigenous	Indigenous	Indigenous
Local names	Impende iyakashika (Bemba) Pende (Nyanja) Mbufu	Wamunyima (Lozi) Madamu (Tonga)	Njinji (Nyanja, Bemba), Impende (Bemba)	Pale, Nkamba (Bemba)	Impende (Bemba)
Classification	Herbivorous	Omnivorous	Omnivorous	Omnivorous	Omnivorous
Growth	Slower growing	Fast growth	Fast growth	Average	Fast growth
Reproduction	Mature in 7 months; spawns every 4–8 weeks if T>20°C	Mature in 4–6 months; spawns every 6–8 weeks if T>21°C	Mature in 4–6 months; spawns 1–2 times a year if T>21°C	Mature in 4–6 months; spawns every 4–5 weeks if T>20°C	Mature in 4–6 months; spawns 1–2 times a year if T>24°C
Temp tolerance	8°C–41°C	8°C–42°C	Tolerates 9°C–41°C	Tolerates 12°C–41°C	Does not tolerate cold
Optimum temp	24°C–32°C	24°C–32°C	24°C–32°C	24°C–32°C	24°C–32°C
Natural Occurrence	All over Zambia	Zambezi river basin	Upper Zambezi and Kafue rivers	Upper Zambezi and Kafue rivers, lakes Kariba, Mweru and Bangweulu	Lake Tanganyika

(Modified from the Peace Corps RAP manual)

**Table 1.** Key attributes of tilapia species cultured in Zambia.

## BMPs for selection of species

### 1. Only stock native species

Tilapia can only be cultured if this species is present in receiving water as affirmed by the Department of Fisheries (DOF) according to established regulations (Fisheries Act No. 22 of 2011). Introduction of exotic or non-indigenous tilapia strains into the natural ecosystem can lead to numerous environmental repercussions such as uncontrolled hybridization with indigenous species leading to a change in stock genetic structure (Hussain 2004). Also, tilapia species are likely to grow better in aquaculture within their area of natural occurrence because of the favorable environment.

### 2. Apply for a permit when transporting live fish

Permission from the DOF is required to translocate or transfer live fish from one place to another. Transport of fish between districts for stocking in fishponds should only be done with a permit from the DOF or with guidance from local DOF officers for smallholders. This is necessary to preserve the genetic biodiversity of indigenous fish species that are present in the headwaters of the area.

### 3. Select the right species for the area

When selecting a species, the farmer should take into account the market, growth rate, and environmental preferences.

## Trainer guide

### Discussion: Native versus exotic species

In Zambia many smallholders in Northern Province are asking for Nile tilapia, but this species is not allowed in the region. Ask the trainees if they know why Nile tilapia is not allowed. Discuss with them the advantages and disadvantages of introducing the species to the area. Why are local species better?

An example for Zambia:

Nile tilapia was imported to Zambia for fish farming along the Kafue River in the 1980s. Fish escaped from culture facilities and spread throughout the Kafue floodplains disturbing the ecology of native *Oreochromis* species (Bhole 2014). Therefore, translocation of Nile tilapia is highly regulated in Zambia, and local tilapia species like the Tanganyika bream are restricted to Northern Province.

### Site selection

When evaluating and selecting sites for earthen fishponds, the main factors to consider are land area, water availability and quality, and soil type. Most of the siting criteria important for reducing environmental impacts of pond aquaculture are also critical in assuring profitability of the venture. For example, selection of sites with proper soils and protection against floods will reduce long-term expenses associated with water use and replacement of escaped stock, while also protecting the environment by reducing water use, reducing infiltration of pond water into groundwater supplies, and preventing escaped fish from entering nearby water bodies. As such, careful site evaluation should be made prior to construction. To avoid problems and mistakes in selection and construction, new farmers should visit the DOF for advice on selecting a suitable area for pond construction.



Smallholder ponds in Luwingu, Northern Province, Zambia.

In Zambia, many farmers are located in dambo areas, which are located in low lying swamps often below flood level. Here ponds are not drainable since water continuously flows in from underground. These areas are also prone to flooding, so these are not ideal sites for fish farming. Some specific BMPs for farmers in these areas are mentioned below.

### BMPs for site selection

#### 1. The source of water should be available year-round and free from contaminants

Water is essential to fill the ponds for stocking, to replace losses due to seepage or evaporation, for water exchange, and to replace water in ponds during emergencies. A reliable water supply is the most essential factor to be considered when selecting a suitable fishpond site.

#### 2. Select a site with environmental conditions suitable for the species cultured

The most important factor to consider is temperature. Ensure that the water temperature is suitable for optimal growth of the species cultured.

### 3. Suitable soil type and quality

The pond soil must have enough clay content to ensure that the pond will hold water. When clay soil absorbs water, it swells up and seals the bottom and sides of the pond. Soil that is too sandy will cause problems; pond banks will erode easily, and water will leak out through the pond bottom. In this case a layer of clay soil needs to be compacted over the pond sides and bottom to prevent water seepage.

### 4. Select a site with a slope

Land should be relatively level since steeply sloped land is not generally suitable for building ponds. A slope of about 1%–4% (trainer should draw these angles on the board or flipchart) is considered ideal since it is able to allow water flow by gravity. If possible, the land must be slightly lower than the water source so that the ponds can be filled by gravity rather than by pumping, which reduces energy inputs and operating costs.

### 5. Accessibility to the site, market and supplies

It is recommended that the ponds are close to the homes of the farmers. The area should be accessible by road to buy inputs and sell products.

### 6. Ensure security of the site

The site should be protected from thieves. The ponds can be located close to the smallholder's house or on a site where other trusted people are present. Another option is to fence the area.

### 7. Comply with all national and local regulations

Follow legal requirements regarding land and water use, and environmental management. Fish farming requires an aquaculture license issued by the DOF accompanied by an environmental assessment. However, since this is too expensive for smallholders, the DOF has developed block Environmental Project Briefs (EPBs) for smallholders in some areas with potential for aquaculture like Lake Bangweulu and Lake Mweru (Shula and Mukuka 2015). A block EPB is an Environmental Impact Assessment (EIA) report of an area as a whole, prepared in respect of projects with very low negative impacts on the environment. Farmers should not engage in aquaculture activities without consulting local authorities and the DOF officers.

## Legal and regulatory framework for aquaculture in Zambia

- Fisheries Act No. 22 of 2011
- Environmental Management Act No. 12 of 2011
- Water Resources Management Act No. 21 of 2011
- Land Act 1995 (Chapter 184)
- Biosecurity Act No. 10 of 2007

## Special BMPs for dambo areas

### 1. The site should have limited flood risk in rainy season

Floods that overtop pond levees result in loss of cultured animals, contamination of ponds with wild aquatic animals, and mixing of potentially poor quality floodwaters and pond waters. In dambo areas the flood risk is high, so a site should be selected where these risks are manageable. Before construction of ponds in a

dambo area, farmers should investigate the history of the dambo in the last 5 years in terms of flooding and water availability. This can be done by consulting other farmers and residents around the area.

## 2. Avoid making a pond on the spring (water source)

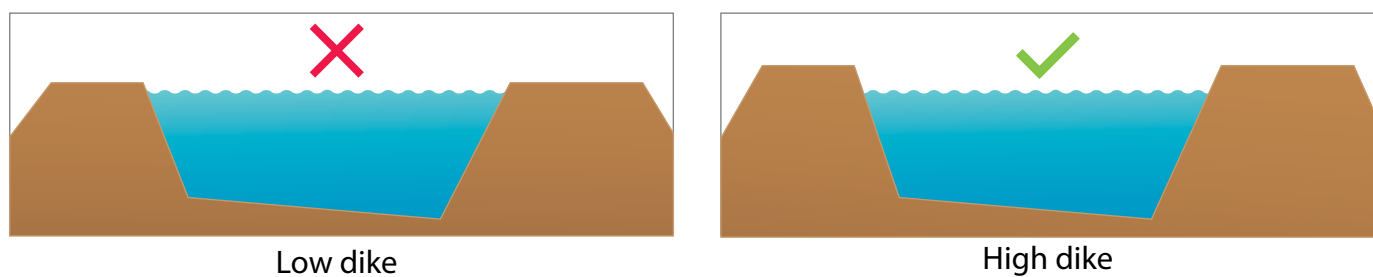
Use a spring as inlet water source and divert the water to the ponds. Do not construct the pond on top of the spring. In dambos with a problem with water supply, a reservoir pond can be made near the source of water, such as a spring, from which water is diverted to fishponds.

## 3. Sites should be protected from flooding

Since flood risk is high, dikes should be elevated if necessary. Ponds should have high dikes and large overflows to accommodate high water levels. Instead of one spillway, ponds in flood sensitive areas can have multiple spillways to allow for quick outflow of water.

## 4. Do not develop fishponds in ecologically sensitive wetlands

Wetlands account for approximately 19% of Zambia's total area. They comprise natural lakes, human-made lakes, open river channels, wooded flooded areas, floodplains, swamps and dambos. Some wetlands of international importance, such as the Bangweulu, Lake Tanganyika and Lake Mweru-wa-Ntipa wetlands, are located in the Northern and Luapula provinces of Zambia, which are also areas of greatest potential for small-scale fish farming. Aquaculture activities should be conducted so as not to disturb these areas unnecessarily.



**Figure 3.** Side view of a pond with low dike system (poor management practice) versus pond with high dike system (best management practice).

## Trainer guide

### Discussion topic: Disadvantages of ponds in a dambo area and solutions

Discuss among the group what the disadvantages of farming in a dambo area are. Once these are identified, ask the group to come up with solutions.

#### Disadvantages:

- Inability to drain pond for harvesting and cleaning
- Risk of flooding
- Water can go from pond to pond.

#### Solutions:

- Increase dike height
- Large overflows
- Dikes should be wide enough to avoid seepage from one pond into the next.

#### Exercises: Soil test

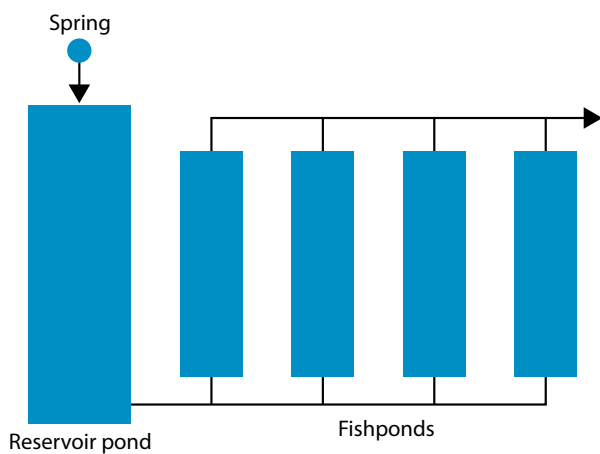
1. Squeeze method
  - Wet a handful of soil with just enough water to make it moist
  - Squeeze the soil by closing your hand firmly
  - If it holds its shape after opening your hand, the soil is good for pond construction.



2. Soil in the air
  - Make a soil ball
  - Throw it in the air
  - If it does not fall apart, the soil is good for pond construction.
  
3. Water permeability test (for multi-day training)
  - Dig a 1 m deep hole in the ground
  - Fill the hole with water to the top
  - Cover the hole with leaves
  - The next day the water level will be lower since the soil has been saturated with water.
  - Refill the hole to the top and cover with leaves
  - The next day, check the water level. If the water level is still high, the soil is suitable for pond construction. If the water has disappeared, it is not suitable for fish farming.

## Pond construction and preparation

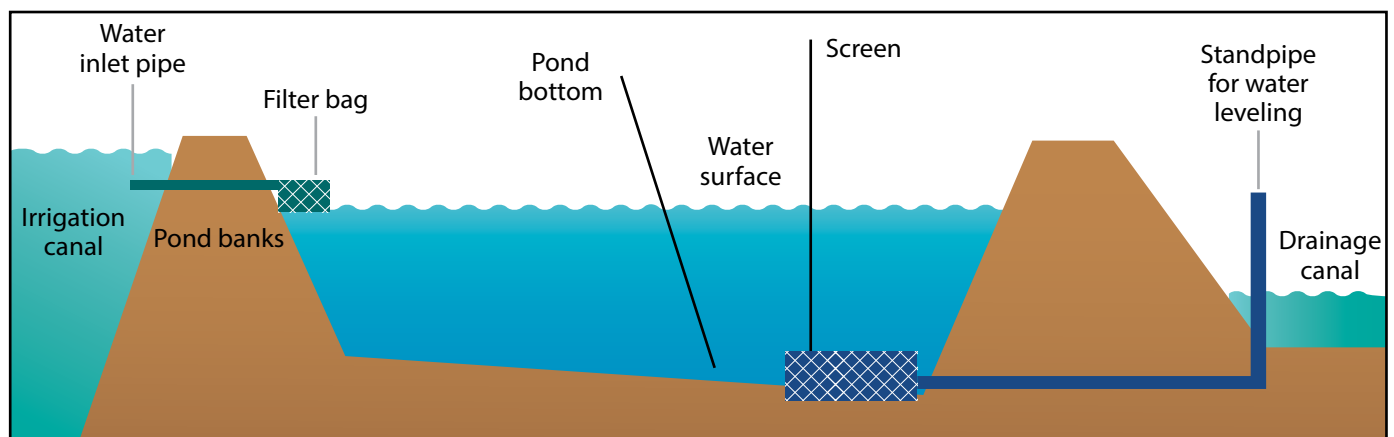
It is very important to consider the layout of the ponds in relation to the topography of the land, water source and drainage. Ponds should ideally be arranged in parallel having two bypasses allowing for independent supply and removal of water (Hussain 2004). Dikes are constructed around ponds to ensure water retainment. Maintaining the right water level in the pond is necessary to regulate temperature, inhibit growth of underwater plants and to keep dissolved oxygen at sufficient levels. In dambo areas, ponds should be constructed when the water is low. Between harvests ponds need to be prepared for the next batch. This includes drying and cleaning of the pond.



**Figure 4.** Parallel arrangement of ponds each having independent water supply and outlet channels with a common source.



Pond construction by Nsombo women in Luwingu, Northern Province, Zambia.



**Figure 5.** Vertical side view of a good pond with all basic features.

## BMPs on pond construction and preparation

### 1. Suitable size and shape of ponds

The best size and shape for ponds depend on production purpose, intensity of production, market schedule, harvesting methods and construction cost. Rectangular ponds are the most practical to construct and manage. Pond size may vary widely from as small as 50 m<sup>2</sup> to 1 ha. From the management point of view and profitability, the DOF recommends fishponds of at least 600 m<sup>2</sup> for smallholders in Zambia. Ideally pond length is double the width.

### 2. Use the right pond depth

Ideally pond water depth should be 0.8 m at the shallow end and increase gradually to 1.2 m at the deep end, with 30–50 cm of freeboard. Ponds entirely dependent on seasonal rains must be deeper in order to hold water longer into the dry season.

### 3. Dikes should have the right height and slope

The pond dike should be elevated at such level so that floodwater cannot enter into the pond. Both inner and outer sides of the dike should be sloped between 1.5:1.0 (33°) to 2.0:1.0 (26°) to prevent erosion. The soil used for the dike should not contain large amounts of rocks, sand, wood or plants in order to avoid leaks. Ensure dike are wide enough between ponds to avoid the risk of breakage and to provide workspace.

### 4. Each pond should have its own individual water supply and outlet

Inlet and outlet canals should be strictly separated; no water flow should be allowed from one pond to another. If necessary, inlet water should be treated in a reservoir or using filtration. The flow of water into each pond must be controlled by valves or shut gates. Inlet water should be screened to keep out wild fish, twigs, leaves and other trash. The outlet should be at the deepest end of the pond so that all the water can be drained out of the pond by gravity. The inlet and overflow pipes should be at least 20 cm above the water surface to prevent fish from escaping. Regularly clean the mesh on the overflow pipe in undrainable ponds where water flows continuously to avoid blockage. Breaking the dike instead of installing an outlet is not a good practice since this causes erosion, will weaken the dike and is labor intensive.

### 5. Effluent water should be settled and screened

Wastewater should go through a sedimentation pond or canal to avoid pollution of the natural environment. The outlet should be screened to avoid the release of dead fish or other waste going into the surrounding environment.

### 6. Dig a ditch for harvesting

To facilitate harvest of the fish, a ditch (2 m wide) should be made in the lowest area of the pond bottom toward the drain outlet.

### 7. Dry the pond between batches

When using drainable ponds, water should be drained from the ponds as much as possible. Then the pond bottom should also be dried until it cracks; this helps to improve soil properties and dispose of some organic wastes.

## 8. Clean pond between batches

Ponds that can be drained completely can be sundried to kill all small organisms remaining in the pond. This should be done for a minimum of 10 days. Applying agricultural lime will increase soil pH and kill harmful organisms.

## 9. Pond maintenance

Check dikes for holes and fix them. Maintain the ditch by lifting mud onto dikes. Re-slope the dykes if necessary. Also check the inlet and outlet canals and maintain their depth to ensure water flow.

## Trainer guide

### Discussion topic: Size of ponds

Discuss the size of ponds with the trainees. Ask the farmers what sizes of ponds they use and what size they think would be the best.

Advantages and disadvantages of small and large ponds:

Small ponds	Large ponds
Easier to catch and harvest fish	Cost less to build per m <sup>2</sup> of water
Easier to manage, maintain and treat for disease	Higher production possible per hectare
Not eroded by the wind easily	More stable and less prone to temperature
	Have more oxygen available for fish

**Table 2.** Small ponds versus large ponds.

## Biosecurity

Biosecurity is a set of preventive measures designed to reduce the risk of transmission of infectious diseases by pathogens (viruses, fungi, bacteria, parasites, etc.) and vectors (wild fish, predators, pests, rodents, domestic animals, livestock and people). The main goal of implementation of biosecurity measures is to protect the farm and the surrounding environment from the introduction or spread of pathogens. These can come from the water source, seed source, feeds, equipment, personnel or waste. Physical biosecurity measures are those that aim at preventing the intrusion of disease-carrying vectors to the farm site, and include physical barriers, water treatment and quarantine. Chemical measures are those used to treat materials before they enter the facility. Other elements of biosecurity are the minimization of impacts of invasive alien species on the environment and avoidance of health risks that may arise through consumption of fish.

## BMPs on biosecurity

### 1. Seed should be healthy and free of disease

Animals entering the farm can present a significant disease risk, especially if the health status is unknown. Therefore, seed should be bought from accredited hatcheries. If possible, fry should be quarantined before stocking in the ponds. This can be done in a hapa in a small pond with no other fish.

### 2. Use clean water supply

Water entering the pond should be clean. No water should be transferred between ponds. Ponds should have intake pipes and outflows to avoid cross-contamination.

**3. Measures to prevent disease entry should be applied to all persons entering the farm**

People can introduce pathogens to a farm, particularly when they have visited other farms. They can introduce pathogens via skin, clothing and footwear. Visitors from farms where they have disease or mortality problems should not be allowed in the farm. The farmers and staff should wear clean clothes and no jewelry. People working at the ponds should wash their hands before work, after eating and after going to the toilet. Contact with the water should be kept to a minimum.

**4. Only use clean equipment**

Fish nets, buckets, containers and other equipment should be cleaned before use with disinfectant (i.e. chlorine, Virukill) and especially between use in different ponds. After cleaning, equipment should be sun dried.

**5. Dispose of waste properly**

Waste, such as domestic waste, dead fish and expired feed, should be disposed properly to avoid risk of contamination and attraction of predators. Sick and dead fish should be removed from ponds as soon as possible. Use a clean scoop net or bucket to remove dead fish. Dead fish may be buried at a safe distance from the ponds.

**6. Implement predator and pest control measures where necessary**

Pests and predators can carry diseases when entering the pond. Animals like birds, snails, frogs and monitor lizards should be kept out of the pond. Monitor lizards, snakes, and birds also consume fish from the ponds. Cover inlets with small mesh, fencing ponds, avoid large trees on dikes, regularly check for dike erosion and install lines above the ponds. Frogs and frog eggs can be easily caught with a scoop net. Drying the pond and liming in between production cycles are the main interventions for pond disinfection and control of pests. Fertilized ponds reduce visibility for the birds. Ensure ponds have a sufficient water depth to decrease the fish scent of a pond. Patrol the pond area regularly and use scarecrows or decoys where possible. Predators and pests must be managed in an environmentally sustainable way; animals must not be poisoned, trapped or shot.

**7. Control weeds and dense vegetation near ponds**

Aquatic weeds provide shelter for vectors and predators. Weeds on the pond dikes and dense vegetation near the pond will be hiding places for predators and other animals. Clear pond dikes from vegetation regularly and avoid using any herbicides as they may be toxic to fish.

**8. Do not let livestock and domestic animals enter the pond area**

Animals should be kept away from the ponds since they can carry diseases or contaminated water. This can be done by making barriers.



## Trainer guide

### Discussion topic: Main risks of diseases at their farm

Discuss with the participants what they think are the main risks for diseases in their farms, and what they can do to minimize these risks. To define the risks, they should also take into account the likeliness that they occur (frequently, never or possibly) and the consequences (do the risks have a big impact).

### Exercise: Spreading disease

In this exercise the participants will walk around shaking hands with the other participants for 30 seconds.

- The trainer secretly selects one trainee to be infected by a disease. The trainee should squeeze the other trainees' hand while shaking hands.
- Once your hand is squeezed, you are also infected and must squeeze other people's hands when shaking their hand.
- When the time is up, all trainees that had their hand squeezed have to raise their hands.

The trainees can see how fast a disease can spread. Fish are contained in a pond and can easily spread disease once infected. Also, people on the farm can spread diseases to each other or to the animals. Even when people or animals do not look sick, they can already spread disease. When animals show signs and symptoms, they should be removed from the pond.





## Stocking

Smallholders require seed that are monosex, uniform in size, free from disease and highly vigorous. Fry quality can be assessed by observing the movement, color, shape, size and responses to feed. Seed should be bought from a reliable source.

Transport of seed from the hatchery to grow-out farms should be carefully planned. Constant vigilance is necessary to ensure that good water quality is maintained and that the fish reach their destination in time. Accessibility and road infrastructure are important when locating a hatchery to ensure easy movement of fish. Usually seed are transported using polyethylene bags in insulated polystyrene boxes or in open containers. During transportation live fish can face stress resulting from the decrease in water quality if fish are not handled properly. They should be purged before transport and provided with clean water and oxygen throughout the journey. In cool water, fish are less active and thus consume less oxygen and produce less ammonia and CO<sub>2</sub>. Temperatures should be adjusted slowly as not to expose fish to sudden temperature changes.

Fish production will normally increase with the number of fish stocked per unit area until the optimum stocking density is reached. The optimal stocking rate for a pond results in the highest quantity and quality of fish production and thus the most profitable. The carrying capacity of a fishpond is largely determined by management practices. When stocking fish in the ponds, they need to be slowly acclimatized to their new environment to avoid stress.

### BMPs on stocking

#### 1. Minimize traveling time of seed to the farm

Since the road infrastructure in Zambia is not always of a high standard, traveling might cause a lot of stress for juvenile tilapia. To avoid unnecessary stress or even mortality, traveling time should be minimized. Arrangements with the hatchery should be made a few days prior to the pick up or delivery. Smallholders are advised to purchase seed from nearby suppliers, but only if the quality is sufficient. Prepare and transport seed during cool hours of the day (preferably 18:00 to 10:00). Drive carefully as not to stress fish.

#### 2. Acquire good quality seed of similar age and uniform size for stocking

Usually fingerlings of at least 1 g average bodyweight are suitable for stocking. Fingerlings should be healthy and free of injuries and deformities.

#### 3. Fish must be obtained from reputable, experienced, disease-free hatcheries

Not every hatchery maintains high standards regarding biosecurity and avoidance of inbreeding. To maximize production, it is therefore recommended to purchase seed from a reliable source, like a government breeding center, commercial hatchery or a well-known breeder farmer. Ask the hatchery to purge the seed before transport.

Seed should not be bought from another farmer or from the wild. Buying wild fish will deplete wild stock and increase the risk of disease/mortalities. Wild fish are not weaned to artificial feed and need time to adapt to a pond.

#### 4. Stock all male tilapia (monosex)

All male tilapia are uniform in size, grow faster and use feed more efficiently which results in a better productivity and profitability. Optimal production requires minimized size differences in the pond, so in-pond reproduction should be avoided. When using mixed-sex seed, reproduction cannot be controlled.

#### 5. Stock seed during cool hours

Seed should be released into the pond during cool hours of the day, i.e. after 18:00 to 10:00. If there is wind, stock on the windward side of the pond.

#### 6. Acclimatize seed to new conditions

Keep the seed bags floating on the pond for 20–30 minutes before releasing fingerlings into the pond to acclimatize fingerlings with pond water temperature. Start feeding the fish 1 or 2 days after stocking to allow them to recover from the stress of transport.

#### 7. Use suitable stocking density

Stock fingerlings at a density of three to five fingerlings per square meter (semi-intensive culture system) depending on water quality and feeding system.

### Trainer guide

#### Discussion topic: Fish transportation

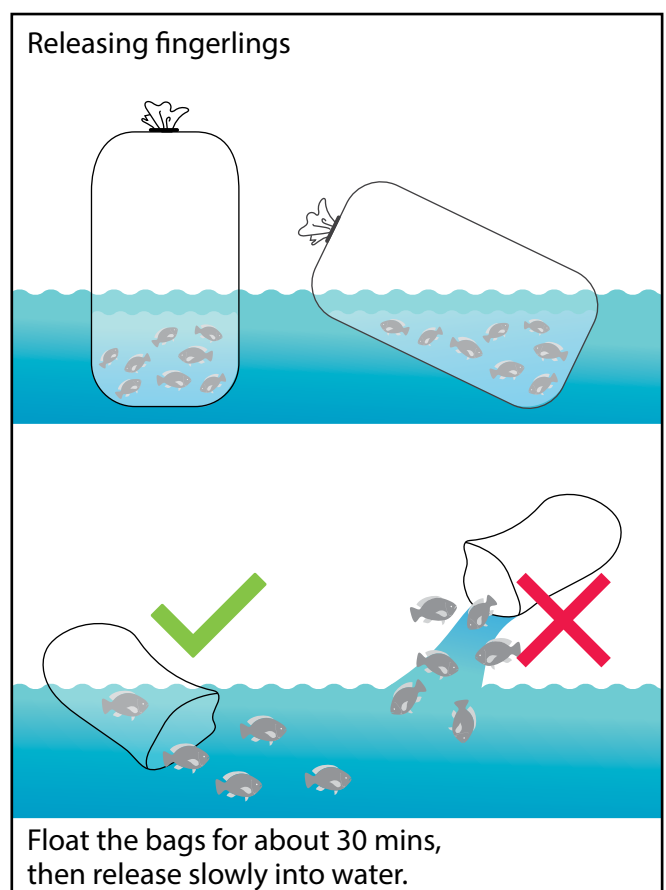
Discuss methods of fish transportation commonly used in trainees' locations. What are the difficulties and how can this be improved?

#### Demonstration: Acclimatizing fry or fingerlings

At the pond, show the trainees how to acclimatize the fish. Use a plastic bag with cold water and air and some floating objects inside (if actual seed is not available, wooden or plastic objects can be used so they can be easily removed from the pond afterward). Ideally use a thermometer to verify the temperature. Ensure to point out the difference in the bags and the pond before floating the bags in the pond. Float the bags in the pond for at least 15 minutes and do not expose them to direct sunlight. Mix pond water into the bag slowly. Let the fish get used to the pond water. Once the temperature of the water in the bag is the same as in the pond, the fish can be released into the pond with care. Open the bag and sink the open side into the water so the fish can swim out by themselves. Observe how the fish swim. If they lie on the pond bottom, this is a sign of being over-stressed from transport, to the point where they might die.

### Nursery

Seed are usually supplied to farms between 0.3 to 1.0 g. Stocking of such small fish directly into



**Figure 6.** Acclimatizing and releasing fingerlings.



production ponds is inefficient because ponds would be far below carrying capacity for several weeks. It also causes high mortalities. Therefore, seed are reared in larger nursery ponds for 1 to 3 months. When a size of 2 to 5 g is reached, weaned fry leave the nursery ponds to be stocked in grow-out ponds (Boyd 2004). Nursing will reduce the mortality of the juvenile fish.

Nursery ponds are usually fertilized ponds. The principal objective of rearing juvenile fish in fertilized ponds is to provide an environment in which fish survive and grow rapidly. This relies on the maintenance of an appropriate size and abundance of food organisms (phytoplankton, zooplankton and macro invertebrates), while simultaneously maintaining water quality suitable for survival and growth. It is important to time preparation and filling of ponds to coincide with stocking to ensure that when juvenile fish are ready to be stocked into the ponds, there has been sufficient time for the ponds to develop suitable blooms of plankton. See section on fertilization later in this module.

## BMPs on nursery

### 1. Nurse fish in hapas

To increase the survival rate, hapas can be placed in ponds to nurse fry for a few weeks before releasing them into open pond water. Hapas can be setup in grow-out ponds, as a hapa of 5.4 m<sup>2</sup> (3.0 m x 1.8 m x 0.9 m) can accommodate 500 fry. Another advantage of the hapa is that you can easily count the number of fingerlings. As hapas are often fouled by uneaten feed, fish feces and attached microbial growth, they should be cleaned with a brush weekly.

### 2. Feed frequently and consistently

The fry should be fed five times daily with high quality powder feed (30% crude protein or more) at the feeding rate of 10% bodyweight per day.

### 3. Regularly grade fish

For optimum survival, it is recommended that fry nursed in hapas are size graded and thinned out once per month. Grading fry by size is achieved by sieving fish through netting, plastic mesh or parallel bars. Several sizes of graders will be necessary depending on the size of fish that will be graded. After grading, the stocking density should be adjusted to the fish size.

Size of tilapia		Recommended stocking density
Centimetres	Grams	No. fish/m <sup>2</sup>
2.5	0.2	750
3.8	0.5	440
5.1	1.0	255
6.4	2.0	143
7.6	5.0	63
9.0	10.0	35
10.0	20.0	20
11.4	50.0	10

Source: [tilapiathai.com/nam-sai-libray](http://tilapiathai.com/nam-sai-libray)

**Table 3.** Recommended stocking density of tilapia in nursery hapas.



## Trainer guide

### Discussion: Use of hapas

Discuss with the participants the advantages of using hapas over stocking fry directly in earthen ponds. Some examples:

- Use of hapas can reduce mortality
- Easy to count number of fry/fingerlings
- Easy feeding

### Feeding

Feed should be well balanced and cost-effective, obtained from a reputable manufacturer, formulated for tilapia and consistently available. High quality feed is essential to obtain high productivity and good fish health. Commercial feeds offer several advantages over low quality feeds, such as better feed conversion, faster growth, lower mortalities and improved water quality.

Feeds should be protected from contaminants (microbes, chemicals, etc.), since these have a negative effect on the cultured fish and can be passed along to consumers through the food chain. Feed can be contaminated through its ingredients or due to improper or long storage. When receiving feed, smallholders should check its quality and labels. Feed should be stored in a dry and cool area protected from pests and potential contamination sources.

Some smallholders utilize farm-made feeds, kitchen waste and natural foods, such as trash fish and agricultural by-products. This practice does not provide the required balanced diets to the fish and can lead to poor growth and nutritional deficiencies (NRC 1993) and poor water quality, if not well managed. It can also encourage the spread of disease and add to the organic load in the pond (Negroni 2013).

Commercial feeds seem to be more expensive, but since they are also much more efficient (lower feed conversion ratio (FCR)) eventually this might lead to higher profit. It may be worthwhile to buy feed with a group of nearby farms to get a lower price and consistent delivery (Hollingsworth et al. 2006).

Feeding practices should maintain water and sediment quality and avoid the risk of biological and chemical contamination. Farmers should follow instructions from feed manufacturers. Feeding rates should be based on a percentage of the bodyweight of fish. This percentage changes with the size of the fish (smaller fish require more feed as a percentage of their bodyweight) and environmental factors, especially temperature. For tilapia, industry recommended feed conversion rates are available, from which feeding rates can be calculated.

Fish must be fed the right size of feeds, and feeding frequency should be adjusted to the fish size. Smaller fish require higher feeding frequencies than larger fish. When feeding, fish behavior should be observed to ensure fish are eating and to avoid under- or overfeeding. Low appetite is a sign of distress and is a reason to test water quality, check fish health, stocking densities and feeding practices. Proper feeding practices can reduce the FCR, reduce feed usage and waste due to overfeeding, and prevent pond bottom and water quality deterioration due to excess feed accumulation.



A female smallholder fish farmer of Kasama District feeding fish at Kasakalabwe Fish Farm, Northern Province.

	Maize (ground)	Farm-mixed fish feed	Commercial feed/pellets
Unit cost of feed/kg (ZMW)	2.2	3.63	8.4
FCR of the feed	9	5	1.5
Total cost (ZMW) of feed used to produce a kilogram of fish	19.8	18.15	12.6

(Modified from Isyagi et al. 2009)

**Table 4.** Costs efficiency of different types of fish feed.

## BMPs on feeding

### 1. Feed should be purchased from a reputable manufacturer

As feed cost represents the largest part of production costs, smallholders should buy the appropriate feed for the fish species. Use high quality commercial feeds and buy directly from the feed mill or trusted dealers. Floating pellets are recommended, as they remain on the surface until consumed and hence it is easier to monitor the fish and track their growth.

### 2. Only fresh, high quality feed should be used

To guarantee optimal growth rate, survival and health of the farmed species, it is important to ensure and maintain feed quality. Therefore packages should be properly labeled with ingredients, storage conditions, expiry date, feeding rate and other necessary guidance in adequate language. Check the content of the feed before feeding; it should be dry and not moldy. Feed should be purchased and used prior to the expiry of their shelf-life.

### 3. Use the correct size

Use the right size of pellets for your fish at each life stage. If the pellets are too big, the fish cannot eat them, since fish swallow feed whole. If the pellets are too small, the fish require much effort to eat enough and this will decrease the growth rate. The feed manufacturer can provide feeding tables in order to inform the farmer on using the right pellet sizes.

### 4. Feed consistently and regularly

The biological rhythm of tilapia will be adapted to their feeding time. This biological rhythm is important for many physiological processes, and if hampered it could reduce the production efficiency of the fish. Therefore, feeding times should be consistent every day. The number of times feed should be distributed per day varies according to fish size. Small fish up to 50 g should be fed 3–4 times/day while large fish can be fed only 1 or 2 times per day, taking into account that the total amount should not exceed the calculated daily feeding rate for each pond.

Bodyweight of fish (g)	Feeding rate (% bodyweight)	Number of times feeds per day
1–5	6–10	5–6
5–25	5	4
25–150	3	3
>150	2	2

**Table 5.** Guide for feeding tilapia at 24°C–30°C using quality formulated feed.

### 5. Use feeding methods that reduce stress and environmental impact

Farmers should follow the instructions of the manufacturer when using the feeds. Feeding practices should ensure the maintenance of water quality. Do not overfeed, since uneaten feed will go to waste and decrease the water quality. Insufficient feeding will lead to poor growth. When using floating feeds, a floating hose ring or pipes can be used to contain the feed and stop it floating away to the pond margins where it attracts birds and is harder for the fish to consume.

### 6. Feed the right amount of feeds

Feeding rates should be adjusted according to fish behavior. Fish should not be overfed (no pellets should be left uneaten), nor should fish be underfed. Sampling should be carried out (see section on fish health) to calculate the right feed amount. In the absence of a weighing scale, it is hard to calculate feeding quantities. Therefore, smallholders can opt to feed to satiation. Use of floating feed enables the monitoring of fish during feeding; feed should be consumed within 20 minutes of being offered to the fish. If fish do not consume all the pellets within 20 minutes, the quantity should be reduced.

### 7. Feed should be stored in a dry, cool and pest-free area

Proper storage of feeds is important to maintain the quality of the feeds, and it is recommended that feed be stored in a cool and dry area to prevent spoilage, mold growth and contamination. No gaps should be present in the storage floor, walls or ceiling to prevent pests from entering the storage. Feed bags should be grouped according to feed type and size. Feed should be stored elevated from the floor on pallets. Only one bag should be opened at a time, and it is recommended that the feed in use be emptied into a container with a seal. Wet, old or moldy feed should be discarded.

## Trainer guide

### Exercise: Calculating feed amount

Present a scenario to the trainees and ask them to calculate the amount of feed needed in small groups.

Explanation	Calculation
Data from your records	Average bodyweight sampling of fish: 82 g; number of fish: 800
Total weight of fish in the pond: Weight x number of fish	$82 \text{ g} \times 800 \text{ fish} = 65,600 \text{ g} / 1000 = 65.6 \text{ kg}$
Total amount to feed daily to your fish: Weight of fish in the pond x daily feeding rate	$3.0\% = 0.03$ $65.6 \text{ kg} \times 0.03 = 1.968 \text{ kg} = 2.0 \text{ kg}$
Feeding portions (for this example two portions):	Morning feed: $2.0 / 2 = 1 \text{ kg}$ Afternoon feed: $2.0 / 2 = 1 \text{ kg}$

**Table 6.** Guidelines to calculating the amounts to feed.

### Exercise: Calculating FCR

The FCR is the amount of food required to produce 1 kg of fish. It is an indicator for performance of the feed, efficiency of the response to feeding and cost-effectiveness of the feed. An FCR of 1.6 means that by feeding 1.6 kg of feed you produce 1 kg of fish.

It is calculated as follows:

$$\text{FCR} = \text{Total amount of feed given (kg)} / \text{Total amount of fish produced (kg)}$$

Ask the trainees why it is important to know the FCR. After this, present them with a scenario and ask them to calculate the amount of feed needed in small groups.

Explanation	Calculation
Data from your sampling	Previous weight of all fish in your pond: 40 kg; current weight of all fish in your pond: 65.6 kg Feed given to fish (from your records) 2 bags of 20 kg = 40 kg in total
Weight gain: Current weight–Previous weight	65.6 kg–40 kg = 25.6 kg
FCR: kg of feed given in kg/weight gain in kg	40 kg/25.6 kg = 1.56 = 1.6

**Table 7.** FCR Calculations.

### Fertilization and supplementary feeds

As an alternative to using solely commercial feeds, some feed companies have also developed special supplementary feed that can be used in combination with fertilization. Small fish feed on plankton in a fertilized pond until they get larger, at which point supplementary feeds with a lower protein content are provided to the fish. This method can be applied to extensive and semi-intensive systems only (<5 fish/m<sup>2</sup>).

The purpose of fertilization is to create a food chain that will increase the productivity of the pond. Nutrients are added to ponds to stimulate the natural production of phytoplankton, zooplankton and bacteria that serve as food for natural prey that in turn serve as food for the fish. There are different types of fertilizers; inorganic fertilizers act by enhancing the primary production of the pond while organic manures can, in addition, act as an immediate source of food for the fish. The success of a pond fertilization strategy depends on the initial drying, tilling and liming of the pond substratum. The fertilization strategy used to enhance fish production will depend on the management system (extensive versus semi-intensive), stocking density and type of fertilizers used (organic, inorganic or a combination). Use of chemical fertilizers is the cheapest method of enhancing phytoplankton in the fishpond since they are nutrient dense and easy to handle. Organic manure may have health hazards since chicken and pigs are possibly fed with growth hormones and antibiotics. Furthermore, they have low nutrient levels and are bulky and difficult to transport.

## BMPs on fertilization and supplementary feeds

**Note:** BMPs for feeding should be applied when using supplementary feeds

### 1. Follow the instructions of the feed supplier for supplementary feed use

Adopt the feeding regime recommended by the feed manufacturer for best results. Do not use compost cribs for fertilization, since these do not fertilize the ponds effectively and reduce the productive surface area of the pond.

### 2. Do not over-fertilize

Adjust fertilization rate and frequency to maintain light-green pond water with a 30 cm Secchi disk reading-see water quality section. If the water is green enough, no additional fertilizer should be added.

### 3. Organic manure should be free of chemicals, antibiotics or hormones

When using chicken, cow or pig manure, make sure it comes from a source where no hormones or antibiotics are fed to the animals.

### 4. Prevent water exchange in fertilized ponds

Do not exchange the water in fertilized ponds or reduce the exchange rate to the lowest level, unless there is an emergency situation. If water is not kept in the pond, the effectiveness of the fertilizer decreases.

### 5. Fertilizers should be distributed evenly across the entire pond surface once a week

Ensure the fertilizer is spread evenly on the entire pond surface. Dissolve chemical fertilizers in water before applying to the pond. Never apply solid fertilizers to the pond since they will fall to the bottom and will not be available for the plankton.

### 6. Fertilize only on sunny days

Fertilizers are generally less active if applied on a cloudy or rainy day.

### 7. Remove aquatic plants from the pond

The fertilizer activity reduces if there are aquatic plants in the pond water, because aquatic plants comparatively absorb more nutrients than phytoplankton.

### 8. Wean fish on pellets

Small amounts of feed should be provided to ponds to train fish on feeding, from the beginning of the seventh week or according to the guidelines of the commercial feed used.

## Trainer guide

### Discussion: Observation of natural food

The natural food in the pond (small insects, phytoplankton and zooplankton) is very small and hard to see. The presence of food is determined by the color of the pond water.

Ask the trainees what colors they have observed in their ponds and what they think effects the color of the pond. What does it mean if the color is darker?

Normally pond water is green, brown, reddish or transparent. Brown water is usually caused by soil particles suspended in the water; it is often a sign that the pond is not fertile. Green colors indicate plankton productivity. Green can range from brownish green, yellow green to blueish green. Brownish green indicates that the blooms have more zooplankton while yellow and blueish green indicate the presence of phytoplankton. Some plankton turns red at some periods in the day. Green water is the best for tilapia production.

For the practical training, take a look at the fishponds on the farm. What is the color of the pond and what does this mean? Is there a difference in water color between ponds?

## Water quality

The aquatic environment is a complex ecosystem consisting of multiple water quality variables. The critical parameters in the pond environment in order of importance are the dissolved oxygen (DO) concentration, temperature, pH, un-ionized ammonia concentration,  $\text{CO}_2$ , nitrite, suspended solids and alkalinity. Each individual parameter is important; however, it is the aggregate and interrelationship of all the parameters that influence the health and growth rate of the fish. Water quality within aquaculture ponds can determine the health of the fish and consequently the success or failure of a fish farming operation.

## BMPs for water quality

### 1. Measure water quality parameters regularly

Ideally water quality is monitored on a daily basis. The following water quality parameters should be monitored:

**Temperature**—Optimum growth for most tilapia species is achieved at  $24^{\circ}\text{C}$ – $30^{\circ}\text{C}$ . Temperature can be measured with a handheld thermometer.

**Dissolved oxygen**—A level between 5.0 and 7.5 mg/L is recommended. Growth and FCR will be affected by chronically low DO concentrations below 3.5 mg/L. Signs of a low DO (i.e. gasping fish, fish at surface, low transparency, fish swim sluggishly) should be checked in the morning.

**pH**—Tilapia can survive a wide range of pH, from 5 to 10, but are said to grow best at pH 6 to 8. pH can be measured using pH strips.

**Transparency**—Transparency is an indicator of water clarity and gives an indication of the amount of suspended solids in the water. It can be measured using a Secchi disk or with the hand method (when submerging arm in the water to the elbow, palm should be visible). Transparency should be measured in the shadow and should be 25–60 cm.

**Water color**—Light greenish, brown-green or greenish water is most suitable for fish culture. Dark brown and dark green are not good for the fish.

**Ammonia ( $\text{NH}_3$ )**—Ammonia exists in two forms: un-ionized  $\text{NH}_3$  (highly toxic) and ionized  $\text{NH}_4^+$  (less toxic). Avoid concentrations of un-ionized ammonia greater than 0.1 mg/L. Ammonia can be measured using test kits.



## 2. Take measures when parameter falls outside its optimal range

Observation	Possible measures
High temperature (>30 °C)	<ul style="list-style-type: none"><li>• Exchange water</li></ul>
Low dissolved oxygen (<3.5 ppm AM, <5 ppm PM)	<ul style="list-style-type: none"><li>• Increase water exchange</li><li>• Stop feeding until corrected</li><li>• Watch for symptoms of parasites/disease</li><li>• Beating/stirring of water-moving water increases DO</li></ul>
Low pH (<6)	<ul style="list-style-type: none"><li>• Add alkaline buffer (sodium bicarbonate, lime)</li><li>• Reduce feeding rate</li><li>• Check ammonia concentration</li></ul>
High ammonia (TAN >0.25 mg/L) or pH higher than 9	<ul style="list-style-type: none"><li>• Exchange water</li><li>• Reduce feeding rate</li><li>• Watch for symptoms of parasites/disease</li></ul>
Transparency too low (<30 cm)	<ul style="list-style-type: none"><li>• Exchange system water</li><li>• Reduce feeding rate</li><li>• Watch for symptoms of parasites/disease</li></ul>
Dark green or brown color	<ul style="list-style-type: none"><li>• Exchange water</li><li>• Reduce feeding rate</li><li>• Measure DO</li></ul>

## Trainer guide

### Exercise: Making a Secchi disk

A Secchi disk can easily be made from a piece of wood or white plastic (e.g. bottom of a bucket) and a rope. Cut the wood/plastic in a circle of 20 cm. Paint it black and white in equal quadrants. In the center, drill a small hole and pass the rope through, securing it with a big knot. Mark the rope in centimeters. A small weight should be attached to the bottom.

Materials needed:

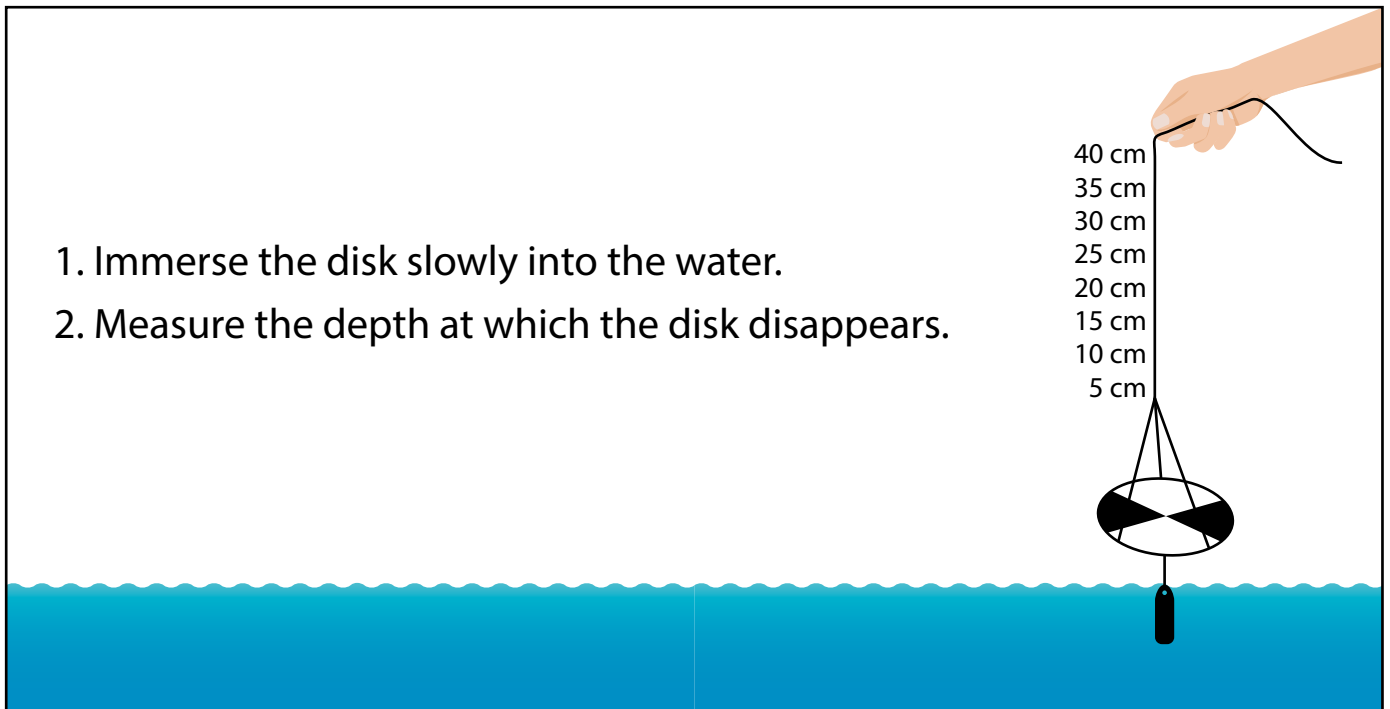
- Wood or plastic pieces
- Paint (white and black)
- Thick rope
- Marker pens
- Tape measure
- Drill
- Saw
- Paint brush

### Exercise: Measuring water quality

Demonstrate measuring the water quality of a pond: temperature, pH, DO, transparency, color and ammonia. Afterward, let the trainees measure the parameters in another pond.

Discuss the results. If results are not within the required levels, discuss actions that can be taken for correction.

**Materials needed:** pH strips, ammonia test kit, thermometer and Secchi disk.



**Figure 7.** How to use a Secchi disk.

## Fish health

Disease outbreaks are of great concern for aquaculture production. Pathogens, like viruses and bacteria have caused heavy losses to aquaculture operators. Disease outbreaks can inflict high mortalities of stock and effect growth rates. The main method to avoid these losses is disease prevention. The best way to prevent diseases is to follow appropriate culture procedures to minimize the potential for microbiological and chemical contamination during aquaculture production.

To monitor fish health, smallholders should be familiar with common clinical signs, signs of stress, and unusual behavior. Changes in behavior may be the first sign that fish are being stressed. Physical changes may become apparent, such as abnormal growths, lesions or discoloration on the body surface, loss of some scales, cloudiness of eyes, eroded fins, clogged gills, etc.

In case a disease does occur, a quick and effective response is necessary. The pond in which the disease is observed should be quarantined, and management should be adjusted. Chemicals or veterinary drugs may be used for disease treatment.

## BMPs on fish health

### 1. Avoid stress of fish

Stress can be minimized by using the right stocking density, regularly feeding the fish, careful handling only when necessary and maintaining good water quality.

### 2. Regular sampling of fish

Fish should be sampled for growth and health once or twice a month. This can also be used to estimate biomass in the pond and calculate the feed ratio. Sampling should be done in the morning. The fish should be weighed as soon as they are caught, then released to the pond again. Around 20–40 fish should be weighed. Fish should not be fed prior to sampling.

### 3. Observe fish regularly

The farmer should regularly check the fish for signs of disease. This can be unusual behavior, physical damages, spots, swelling, etc. A healthy fish has a good appetite and is an active swimmer.

### 4. In case of disease outbreak or high mortalities inform the authorities

If farmers encounter unusual high mortalities or observes signs of disease, they should notify the DOF as soon as possible.

### 5. In case of a disease outbreak, quarantine the pond

Make sure no people enter the pond area except authorized persons if necessary. Do not move equipment out of the pond area.

### 6. Proper use of veterinary drugs and chemicals

In case veterinary drugs are used to treat a disease, these should be administered according to the instructions of the manufacturer. Only chemicals and veterinary drugs approved by the Environmental Management Agency may be used (Fisheries Act No. 22 of 2011 (Section 48)) and should be administered by authorized personnel only. Fish should not be harvested before the end of the withdrawal period (the time in which residue may be found in the edible parts of the fish) of the product, which can be found on the label of the medicine. Residue levels should be below the maximum residue level of the veterinary drugs or chemical.

## Trainer guide

### Discussion topic: Symptoms of disease

Ask the trainees if they have encountered any signs or symptoms of disease in their farm. What other signs do they know of? Explain to them the various other signs common for tilapia to look out for.

Common clinical signs of diseases and parasite infections in tilapia:

- fish reduces or stops feeding
- lesions or hemorrhages on the body surface or eyes
- tail and fins start to rot
- gills become pale and damaged
- cotton-wool like fungi observed on fish body
- white spots observed on the body and fins
- black and white spots or cysts present 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
- cloudy and opaque eye
- swelling of internal organs, such as liver, kidney, gall bladder and spleen.

Please also refer to the poster 'Tilapia major clinical signs' in appendix 3 for visuals of the different symptoms.

### Exercise: Calculate average bodyweight and total biomass

Explain to trainees how to calculate the average body weight (ABW) and total biomass. Then provide them an example of sampling results and let them do the calculation. Check if they did the calculation correctly.

The ABW is calculated by dividing the weight of the sample of fish by the number of fish in the sample:

Estimate total fish biomass based on the average weight of a sample fish.

Ensure to deduct the mortalities from the total number of fish stocked.

Explanation	Calculation
Data from your sampling	Number of fish caught: 54 Total weight: 521 g
Average bodyweight of one fish: Total weight/number of fish	$521 \text{ g}/54 \text{ fish} = 9.65 \text{ g}$ rounded to 10 g
Actual number of fish: Initial fish stocked minus mortalities	Initial number of fish stocked: 1100 Dead fish (get this from your records) : 63 = $1100 - 63 = 1037$ fish
Actual weight of all fish in your pond: Number of fish x average bodyweight; convert g to kg (divide by 1000)	$1037 \text{ fish} \times 10 \text{ g} = 10370 \text{ g}$ $10,370 \text{ g}/1000 = 10.37 \text{ kg}$

**Table 8.** How to calculate the estimated total weight of fish (biomass) in a pond.



Photo credit: Tabitha Mulilo/WorldFish



# Harvesting and post harvest management?



## Harvesting

Harvesting of fish is the final step in the farming cycle and should be carried out in an efficient and safe way. Harvest should take place according to fish size and consumer demands.

The choice of harvesting equipment depends on the size of the operation, available labor, frequency of use, available capital, preferred harvest method, and volume and sizes of fish harvested. The most common type of harvesting equipment is the seine net. Seines work well in large regular-shaped ponds with relatively flat, unobstructed bottoms. Ponds that are not drainable can be harvested with a seine net. However, the only reliable way to harvest all fish from a pond is to drain it completely. This involves a combination of draining and seining. Avoid using a seine in very shallow water because it stirs up the mud and causes low DO and high toxic gas conditions which can be extremely stressful to fish. Shallow water can also warm quickly in hot weather which may greatly stress the fish.

Physical damage can be caused by incorrect handling during harvesting and by faulty equipment. This will affect the quality of the product, so it is important to handle with care, act rapidly and use appropriate materials.



Photo credit: Tabetha Mulilo/WorldFish

## BMPs on harvesting

### 1. Ensure that prior arrangements are made for transport and market before harvesting

Harvest should be planned well to avoid loss of fish due to transport delays or a no-show of buyer. Ensure that clear agreements are made in advance with the buyer. Harvest and sorting equipment should be cleaned and prepared before the harvest. Also make sure there are enough people to work on the harvest. Harvesting is best done during the early morning when water temperatures are lower and sunlight is less intense.

### 2. Only healthy fish of good size should be harvested

To ensure good quality fish and a happy consumer, only harvest good size fish 200 grams and above and do not sell damaged or unhealthy fish. To determine the health status, size and quality of the fish, sampling can be carried out prior to the harvest.

### 3. Stop feeding fish before harvesting

It is important to take fish off feed before they are harvested for 1 or 2 days, especially if fish will be transported long distances. Undigested food can be regurgitated in the transport tank and foul the water quality. Fish are also hardier and less stress occurs when their stomachs are empty. If fish have been fed medicated feed, be sure that the proper withdrawal time has passed before they are harvested for processing.

### 4. Ensure proper drainage

Make sure the drain canal can accommodate water to allow for complete drainage of the pond. Drain the pond quickly and close the supply inlet before draining. Cover the outlet with a net to avoid fish escaping.

### 5. Grade fish

If necessary, grade fish by size according to the market requirements. Depending on the available market, the size of fish may determine the fish prices. Use handling procedures as describe below in the handling and transport section.

### 6. Clean fish

Harvested fish should be cleaned with potable water to wash off dirt and mud.

## Trainer guide

### Discussion topic: Harvest equipment

Discuss with the smallholders which harvest methods and equipment they use at their farm. What are the advantages and problems they encounter? Come up with a suitable harvest method that works for the smallholders and follows the BMPs mentioned in this section. Examples of harvest materials are seine net, gill net, scale, scoop net, hapas, baskets, buckets or containers, and clean water.



## Handling and transport

How fish handled during and after harvesting plays a large role in the quality of the final product. Fish quality is determined by appearance, odor, flavor and texture, nutritional value, consistency and food safety. Fish quality is important for marketing purposes and food safety. Fish must be handled safely and hygienically (avoid risk of contamination by using clean equipment and handling environment). If fish are handled and prepared well, fish can be stored for a longer period of time while maintaining quality. Staff involved in fish handling should be familiar with personal hygiene measures and food hygiene. During and after harvesting, fish should be checked on quality.

Fish start decomposing as soon as they are slaughtered. Examples of signs of spoilage are change in color or texture (eyes, gills), an unpleasant odor and an undesirable taste. Fish spoilage can lead to foodborne illness, which causes a danger to public health.

Chemical, physical and biological hazards pose a risk to food safety by contaminating fish resulting in a decrease in quality. Contaminants can be introduced from water or ice, cleaning agents, drugs, pesticides, physical objects, contact surfaces, people and pests.

The most essential practice to maintain the quality of the fish and prevent spoilage is proper time and temperature control. After harvesting, it is necessary to maintain an uninterrupted cold-chain (a series of storage and distribution activities that maintain a certain temperature range) to ensure food safety and quality. Chilling should commence as soon as possible after harvesting, and fish should be transported and processed with care and minimum delay. Exposure to sun and wind should be minimized. Temperature should be kept below 4°C since bacteria reproduce rapidly between 4°C and 60°C.

## BMPs for handling and transport

### 1. Use easy to clean buckets, baskets or containers

Use easy to clean and smooth materials for storing and transporting harvested fish. Sacks may damage the fish, so these are not recommended. Use plastic buckets, baskets or containers with a smooth surface to prevent damage to the fish. Transport containers and equipment should be designed to minimize physical damage and allow for rapid handling of fish. Containers should allow melted ice water to drain.

### 2. Handle fish gently

Handle fish with care to avoid physical damage that may accelerate the spread of bacteria from gut, gills and skin to muscle tissue. Clean the fish with clean water before storing or transport. Place fish in a box/container without bending the body. Do not overcrowd the fish in one box/container. Do not make the fish touch the side of the box/container.

### 3. Ensure personnel handling fish follow good hygienic practices

People handling fish should wash their hands, wear clean clothes, cover their hair, do not eat, cough or spit, wash work tools and cannot wear jewelry.

### 4. Fish products should be stored under conditions that prevent deterioration and spoilage

This can be done by controlling temperature and humidity. Fish should be kept in a clean place and protected from contamination by pests and chemical, physical and microbiological hazards. Keep fish shaded from direct sunlight and kept in a cool place. This practice should be followed until the fish are picked up by the buyer or put on ice or in a freezer.

**5. Fish should be put on ice or in freezer as soon as possible**

Fish should be transported in refrigerated trucks or in containers with ice or ice slurry (1:1 ratio of ice to fish) to ensure temperature below 4°C and close to the temperature of melting ice during the whole transport period. When chilling fish, it is important to use the right quantity of quality ice for effective cooling depending on the required temperature, type of containers, storage and transport time and other factors. Flake, tube, or crushed ice should be bought from an approved supplier. Ice should be manufactured with clean potable water. Fish should be arranged in layers with ice. The best period to transport fish is during the night or early morning since the hottest hours of the day should be avoided. Records of temperature should be kept.

**6. Transport conditions should avoid contamination from surroundings**

Fish should be protected from bacteria and other contaminants coming from air, soil, water, oil or chemicals. This can be done by using a closed truck or closed containers.

## Trainer guide

### Discussion topic: How long does it take for fish to spoil?

Discuss with trainees different situations. Ask them what they think the temperature will be if the fish are kept under the sun, in the shade, in a cooler and on ice and how long they think the fish will stay fresh and suitable to eat.

Situation	Temperature (°C)	Time it takes fish to spoil
Kept in the sun	25–35	6–8 hours
Kept in shade	20–25	12–16 hours
Kept in a cooler- no ice	5–10	5–7 days
Kept in ice	0	14–20 days

**Table 9.** Fish spoilage related to temperature.

### Exercise: BMPs or not?

Show the trainees the pictures (on a projector or printed) and ask them which practices are BMPs and which are not.

## Marketing

The goal of a commercial fish farm is to make a profit. In order to do this, smallholders need to adjust their activities to the market. The product should be available when the market demands, adequate volumes should be produced to sustain the target market and the product should be sold at a competitive price. In Zambia possible buyers of fresh tilapia are supermarkets, hotels, schools, church, markets and fish traders.

## BMPs for marketing

### 1. Pick a suitable market location

If the farmer is unable to transport the fish in a hygienic manner while maintaining a cold chain, the fish should be marketed locally, or the buyer should pick the fish up from a place close to the farm.

### 2. Ensure market before harvesting

It is important to identify a buyer for the fish before it is time to harvest. Make the necessary arrangements with the buyer before harvesting the fish to avoid unnecessary spoilage.

### 3. Produce a marketable product

Ensure the fish that is sold are the right size and quality for the market. In Zambia the size of the fish should be at least 200 g, but inquire with the buyer what size they prefer. A good growth and quality can be obtained by following the BMPs mentioned in this training manual.

### 4. Be part of outgrowing schemes

A way to ensure there is a market for the fish is to participate in an out-grower scheme whereby seed and feed are usually provided by the private sector and the fish are bought back from the farmer by the same company.

### 5. Link with private sector player that provides extension services

There are several players from the private sector in Zambia that offer extension services to the smallholders. These companies sell feed and seed, training to smallholders. They also assist in finding buyers for fish.

## Trainer guide

### Exercise: Marketing

There are four main ways to attract customers. Ask the trainees what they think these are.

1. The product itself (quality): A good quality product will make customers come back and buy again.
2. Price of the product: Price is less important than we think; most people want best value for money. Sometimes a low price will make people think that the product has a low quality.
3. Place of business: The distance from the business to the customer is important; how far is the buyer willing to travel to get your fish?
4. How the product is promoted: How does the customer know about your product?

It is hard to be the best in all four of these areas. This exercise helps trainees understand which of the four are the most important for their business.

- Place drawings of symbols for Product, Price, Place and Promotion at four different places in the room.
- Ask the participants to imagine they are going to buy tomatoes. What would be the most important to them: the price, where to buy it, the quality of the tomatoes or how it is promoted (how the seller presents his product)?
- Each trainee will go to the drawing according to what they think is most important to them.
- Ask some of the trainees why they chose that drawing.
- Now try again with other products (like pens, bread, shoes) and finish with fresh tilapia.



**Figure 8.** The four elements of marketing.

Finally, ask the participants what they have learned? The exercise shows how people buy different types of products for different reasons. What is most important for smallholders and what is next? How can they use this to sell their fish?



Photo credit: Gibson Zulu/Worldfish





## Business planning

Starting an aquaculture business does not come without risks. It is therefore important to be well informed and prepared. It is advised to start with business planning. It is a tool to determine if profit can be obtained in the future and to apply for funding. Business planning includes setting objectives, determining market potential, production feasibility and financial feasibility. Important factors that need to be considered before investing in an inland aquaculture enterprise include availability of a suitable site, suitable conditions for fish species, and market potential. Land, water, capital, a market, access to supplies and management skills are essential to successful fish farming.

Even if farmers are illiterate, they can still make a business plan. They can draw or ask someone else to write it. The most important thing about doing a business plan is thinking ahead.

## BMPs for business planning

### 1. Identify the necessary needs of the business

Ensure a good site is available for pond aquaculture, as well as access to inputs and market.

### 2. Ensure capacity of the smallholder

Determine if the smallholder has the knowledge and skills to set up and operate the farm. If skills or knowledge is lacking, smallholders should participate in training programs. Smallholders should also have the right attitude to start a business; they should be willing to invest money and time in their business and have a sense of ownership. They should not rely on others for the inputs or help.

### 3. Ensure financial feasibility

Determine if the smallholder has the means to provide the initial investment (own capital or loan) and make calculations to ensure profitability of planned business.

## Training guide

### Exercise: Business planning

Ask the participants to answer the following questions:

1. What product or service will your business provide? (selling good quality fish)
2. Who will be your customers? (fish traders, hotels, supermarkets)
3. Why will your customers buy from your business, rather than from our competitors? (good size, high quality fish)
4. Will you plan ahead in days, weeks or months? (months, as per growing cycle of fish)
5. What important equipment and supplies will be needed, and what will they cost? (digging tools, feeds, seed)
6. What is your best guess of the total sales and expenses for each period? (how much are seed, feed and how much do you sell fish for?)
7. How much money is needed to start the business and keep it running until it makes a profit?
8. Who is going to provide this money? (farmer, loan)
9. Who is starting the business, and what skills do they have that should enable them to succeed? Do they need training? Does the person have the right mind-set and attitude to start a business?

If they can answer all these questions, they have a good business plan. The trainer or other farmers can help them answer these questions. Regarding the question on costs and profit, it would be good if the trainer does some research on prices in the area where the smallholders are located so that during the training some calculations can be done.

## Production planning

Planning stocking and harvesting will influence the cash flow, especially if the smallholder has more than one pond. By stocking ponds at different times, the expenses for seed and feed as well as the income will be spread over time. However, a disadvantage of this is that harvest and transport need to be done more frequently. Therefore, the farmer should look at his financial situation as well as the market to decide what the most suitable production plan is. Before buying seed, the stocking density needs to be decided. When planning the production, the smallholder also needs to know the size of the seed (ideally >1 g) and the FCR of the feeds used. After a few batches, the smallholder will know how fast the fish grow so that harvesting can be planned more carefully.

## BMPs for production planning

### 1. Make the necessary calculations and preparations

Before stocking think of selling first. Find out what size of fish is preferred by the market and for what price you can sell the fish. Grow fish up to a size that is both profitable and easy to sell. Calculate the number of fish that can be stocked in the farm and the costs of the seeds. Then calculate the amount of feed you need for these seed to grow to market size and the costs of feed. With this information the amount of profit that can be made can also be calculated.

### 2. Ensure you have secured enough money to buy inputs

You need to have enough money to buy the seed and feed until the first harvest. After your first harvest, you can use your earnings to buy new seed and feed. What is left is your profit.

### 3. Ensure there is a market available at the time of harvesting

Do not wait to look for a market until the fish are ready to be sold. Before stocking the fish you should already know that there is a market to sell your fish.

## Trainer guide

### Discussion: Prices of inputs and outputs

Ask the trainees how much they pay for seed (as well as what size, type (mono or mixed)), commercial feed (per kilogram) and how much they get for their fish (per kilogram). Write their answers on the board.

### Exercise: Production plan

Use the numbers from the discussion to make a production plan.



	Guiding question	Answer	Example
1	Size of fish for market	What size will you sell your fish?	300 g
2	Growing period (number of months)	How long do farmers take to grow their fish to this size?	6
3	Number of ponds	How many ponds do the smallholders have?	2
4	Size of each pond	Total area of the pond	600 m <sup>2</sup> (20 m x 30 m)
5	Number of fish per pond at four fish/m <sup>2</sup>	Fish stocked in one pond? (600 m <sup>2</sup> x 4 fish/m <sup>2</sup> )	2400
6	Total number of fish	Row 3 x answer row 5	4800
7	Amount of kilograms of fish harvested	Answer row 6 x answer row 1 divided by 1000	1440
8	Feed needed (kg)	Answer row 7 times the FCR (use 1.5 here)	2160
9	Money needed for seed	Answer row 6 x the price discussed	ZMW 4800 (ZMW 1 per piece)
10	Money needed for feed	Answer row 8 x price of feed/kg	ZMW 25,920 (ZMW 12 per kg)
11	Other costs (transport, equipment)	Will you spend any other money on your farm?	ZMW 2000
12	Total money needed	Answer row 9 plus answers row 10 and 11	ZMW 32,720
13	Potential sales	Answer row 7 minus 10% mortality x sales price discussed	1296 kg x ZMW 30/kg is ZMW 38,880
14	Potential profit	Answer row 13 minus row 12	ZMW 6160

**Table 10.** Developing a production plan.

## Finances

It is important to keep track of the money in a business. Both money that is spent (costs) and money that comes in (income). The income minus the expenses are the earnings of the farmer. The simplest way to keep track of the money in your business is by keeping a cash journal. This can be done in a small notebook. In the cash journal you write all your expenses and income so that you can calculate your balance.

Date	Description	In	Out	Balance
1-1-2019	Farmers savings	1000		1000
1-1-2019	Digging materials & pipes		350	650
12-2-2019	Seed (200 pcs) 1 g		200	450
12-2-2019	Feed (3 bags x 15 kg)		300	150
16-4-2019	Feed (2 bags x 15 kg)		200	-50 (150-200)
28-9-2019	Sales 36 kg	1116		1066

**Table 11.** Cash journal template.

In the first column the date is written, while in the second column a description of the expenses or income. For income you write the amount in the third column, and for expenses in the fourth column. To find out your balance (income minus expenses), you take the last balance and add the amount in the IN column and deduct the amount in the OUT column.

## BMPs for finances

### 1. Keep receipts of expenses and sales

When buying supplies for the farm, always ask for receipts and keep them. These serve as records for your expenses. Also, when selling the fish, it is advisable to have the buyer sign a receipt. These receipts can then be used to make the entries for the cash journal.

### 2. Keep a cash journal

Consistently keep a cash journal. This should be done on a regular basis, preferably when the transactions occur, so nothing is forgotten.

## Trainer guide

### Exercise: Making a cash journal

Divide the trainees in small groups of three to four persons. Provide the groups with an empty cash journal. Then read the following story to them and ask them to put what they hear in the cash journal.

Ms. Tabitha decides to start a fish farm because she has seen her neighbor making some money with it. She has always liked to take care of animals and has just lost her job. She has ZMW 1200 saved up and buys some tools for digging his ponds. She has a piece of land where she can make two ponds of 10 by 10 meters. Once she finished digging her ponds with the help of her neighbor, she buys 400 tilapia fry from the hatchery in the next village. These cost her ZMW 400. She needs to buy feed for the fish. The shop sells this for ZMW 60 per bag. One bag is 15 kg and he buys two bags. A few months later she runs out of feed, but her fish are growing well. She buys a total of eight bags more, totaling ZMW 480. This should take her fish up to market size. It takes her fish 7 months to reach 250 g. Out of the 400 fish, she has 365 left so she sells all her fish for a total of ZMW 2370.

Take two or three cash journals and discuss them in front of the participants to correct mistakes and explain it further.

## Record keeping

Record keeping is an essential part of adoption of BMPs on a farm. Properly kept records are the best sources of information on management of a fish farm. They keep track of farm activities and serve as a basis to make business decisions.

Feeding records give information about the amount, type and quality of the feed. They can be used for day-to-day management, adjustment of the feed ratios, estimating feed conversion efficiencies and growth rates. Disease and treatment records are necessary to help keep track of disease occurrence and can be used to adjust adoption and development of BMPs where necessary. They provide information about the health status of fish and can help ensuring important treatments given at the right time. Proper records of water quality should be kept in order to detect problems well before they become a threat to the fish.

Not only the farming activities should be monitored and recorded, but also the finances of the farms should be consequently recorded. Keeping a financial administration will help track expenses, investments and profits, and is necessary for tax purposes. Records can also provide a basis for farm credits and financing. Typical financial records include purchases of farm inputs, personnel costs, maintenance and investment costs, and sales records.



Female smallholder fish farmer taking farm records in Kasama District, Northern Province, Zambia.

## BMPs for record keeping

### 1. Keep records on feed amount and type, stocking and mortality and finances

The amount and type of feed should be recorded. The number of fish stocked in each pond and mortalities per pond should also be recorded. The finances should be kept in a cash journal (see finances section).

#### **The following records are useful to keep:**

##### **Water quality monitoring**

All quality parameters discussed in the water quality section should be recorded per pond. First note the date and time followed by the value.

- Temperature
- Dissolved oxygen (DO)
- pH
- Transparency
- Ammonia.

##### **Feed management**

- Origin of feeds (e.g. supplier details)
- Feeding records (e.g. quantities of feed used, bag numbers)
- Storage and control records (e.g. checking expiry dates, verifying the First In, First Out system).

##### **Management of chemicals and veterinary drugs**

- Origin of the chemicals and veterinary drugs used on the farm
- Required records for every application of drugs and other chemicals should include the treatment start date, treatment stop date, compound used, diagnosis and symptoms, dosage, withdrawal period, MRL, identity of ponds where the drug was applied, and harvest date for the treated ponds.

##### **Postharvest management**

- Species
- Harvest date and slaughter date
- Origin (pond number)
- Treatment history.

## Trainer guide

### **Exercise: Example of record book**

Discuss with the trainees the records in the sheet. Let them check if something is out of the ordinary (DO was low a few times, so feeding was stopped). What can they do with these records? (i.e. How old are their fish? What could be the reason for mortalities?)

The smallholders can use this template for their farm as well. Note that this is not the first page of the notebook; fish are around 3 months old in this example.

Records	
Pond number:	1
Stocking date:	03/08/2018
Species:	<i>O. Tanganicae</i>
Number of fish (#):	200
Harvest date:	
Harvest volume (kg):	

Date	Feed		Water Quality Parameters					Health Check Stock	
	Amount	Type/size	Temp.	DO	pH	Ammonia	Transparency	Mortality	Particulars
07/11/2018	0.2	Pre-starter 40%	23	5	8	0	30 cm	None	
08/11/2018	0.2	Pre-starter 40%	24	5	7.8	0	35 cm	None	
09/11/2018	0.25	Pre-starter 40%	23	2.5	7.5	0	35 cm	None	Fish gasping at surface
10/11/2018	0	Pre-starter 40%	25	3	8	0	35 cm	None	
11/11/2018	0.2	Pre-starter 40%	24	4	8	0.25	35 cm	None	
12/11/2018	0.25	Pre-starter 40%	24	5	7.5	0	35 cm	None	
13/11/2018	0.25	Pre-starter 40%	24	6	8	0	35 cm	None	
14/11/2018	0.25	Pre-starter 40%	24	6	8	0	35 cm	None	
15/11/2018	0.25	Pre-starter 40%	25	5.5	7.5	0	35 cm	None	
16/11/2018	0.25	Pre-starter 40%	24	6	8	0.5	35 cm	None	
17/11/2018	0.25	Pre-starter 40%	24	6	8	0.25	35 cm	None	
18/11/2018	0.25	Pre-starter 40%	25	6	8.5	0	40 cm	None	
19/11/2018	0.25	Pre-starter 40%	26	6	8	0	40 cm	None	
20/11/2018	0.25	Pre-starter 40%	25	6	8	0	40 cm	None	
21/11/2018	0.25	Pre-starter 40%	25	5	8	0	40 cm	None	
22/11/2018	0.25	Pre-starter 40%	26	5	8	0	40 cm	None	
23/11/2018	0.25	Pre-starter 40%	24	5	8	0	30 cm	None	Damages in 2 fish (20 sampled)
24/11/2018	0.25	Pre-starter 40%	24	3	7.8	0	35 cm	None	
25/11/2018	0.25	Pre-starter 40%	23	3.5	7.5	0	35 cm	1 fish	
26/11/2018	0.3	Fish starter 38%	25	4	8	0	35 cm	2 fish	
27/11/2018	0.3	Fish starter 38%	24	5	8	0.25	40 cm	None	

**Table 12.** Example of records.



With a complete set of records (after harvest), they will have the following information:

- how long the fish took to grow to market size
- how much feed was fed (can be used to calculate FCR)
- the temperature changes during the year
- the total number of mortalities and reasons.

## Clusters

BMPs can be adopted by individual aquaculture operators or by collectives like informal farmer's organizations, cooperatives, federations, unions or associations. Collective action can help smallholders to overcome the challenges that come with accessing markets. Another challenge often found by smallholders is access to reliable supplies, financial services and transport services.

By forming clusters, smallholders have experienced improved yield, less disease occurrences and economic benefits. Clusters can improve marketing using bottom-up pressure. It brings harmony and well-being to the community and has benefits in meeting food quality and safety requirements. This is done by collectively purchasing inputs and services, processing and marketing products, and implementing BMPs.

Characteristics of clusters are common needs and interests, interdependence and an overlapping field of work. They need good leadership, defined group activities, capacity to provide services and benefits to their members, manage finances, and mobilize credits.

### Advantages of clusters

- Accessing input (seed, feed) and services (extension, market) becomes convenient when smallholders are organized in groups/clusters.
- Knowledge sharing and provision of technical support by extension officers becomes more efficient.
- Construction of ponds can be organized as a group effort.

### Characteristics of clusters

- A farmer group should ideally consist of about 15 to 30 members.
- Men and women should have equal chances within the cluster (e.g. in leading positions). Ideally, men and women should be equally represented in a cluster.
- Youth members of the community should be encouraged to be part of the cluster.
- The group members should possess at least one fishpond per household.
- Members of the group should meet in a regular interval (at least once a month) to share their experiences with respect to the growth and performance of fish, discuss problem(s) encountered, and reach a solution.

## Trainer guide

### Role play exercise: Clusters

This exercise will show the trainees what the advantages of working together in clusters are. Choose 10 trainee volunteers and ask them to get in front of the audience.

Round 1: Appoint one trainee to play the feed supplier, one the hatchery manager, one a fish trader and the other seven play individual farmers. It is best to shortly brief the feed supplier, hatchery manager and fish trader in advance or play one of them yourself. You can give them cards with the following text or just explain this to them:

Feed supplier:

- You sell a minimum of ten 15 kg bags per order
- Fixed price for all customers is ZMW 60 per 10 kg
- Feed has to be picked up from one of the stores.

Hatchery manager:

- You sell mono and mixed sex seeds
- You sell 0.3- and 1-g fingerlings
- The farmers need to pick up the seed from the hatchery.

Fish trader:

- You negotiate the price with each farmer
- You pick up the fish if they sell over 500 kg
- The minimum size you buy is 200 g.

Ask the farmers to talk to the feed supplier, the hatchery manager and the trader to make the necessary arrangements for their farm. For example, when talking to the hatchery manager, they need to discuss the number of seed they need, the price, the species and quality, the size, and transportation to the farm (who will arrange this). With the trader they need to discuss the size of fish he needs, the price, whether he will pick up the fish or the farmer will deliver it.

The group can discuss for 10 minutes. After this ask the farmers what they have arranged with their contacts. Most likely not all farmers had time to talk to all of the company representatives. Also, they will have different outcomes. Identify problems that the farmers have. Are there arrangements that are not suitable for them (i.e. transport of fish to the trader, minimum quantity of feeds to buy)?

Round 2: Now repeat the exercise, but in this case the farmers are functioning as a group, which means that they will all talk to the companies together. The roles of the feed supplier, hatchery manager and fish trader remain the same. See if they can make arrangements as a group with the companies for their benefits.

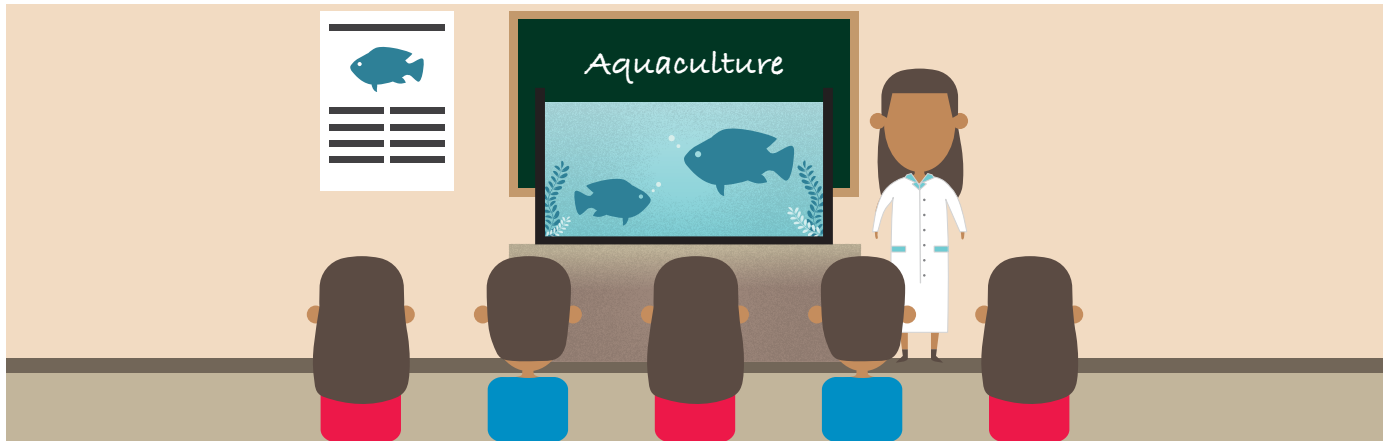
Did they manage to organize things better? Solve some of the problems identified in round one.

- Were they able to put their feed order together to reach 10 bags?
- Did they put their money together to pick up the feeds and seed?
- Did some farmers manage to get a better price for their fish?
- Did the group manage to sell 500 kg together so the fish trader can pick it up or do they need to add more farmers to their cluster? This reduces the risk of spoilage due to transport problems.



## Training methods

It is recommended to use a participatory and gender-responsive approach. Smallholders, especially women and youths, should be able to share their own experience, participate actively and be able to achieve active learning. This manual includes a set of training guides for each topic with suggestions for topics for group discussions, brain storming, practical exercises and questions. It is advised to have a maximum of 25 trainees to facilitate easy communication between trainer and trainees.



**Figure 9.** Private sector smallholders training session.

## Language

It is important to communicate in a language that the trainees understand. In Zambia, there are a lot of different languages spoken, so the trainers should be able to speak a language that the trainees will understand.

## Place of training

Practical training is essential for smallholders, so the training should not only take place in the classroom. Training can start in the classroom to explain the theory, but demonstration and practical training are also needed. This can be done at demonstration farms. It was found that when the training is in the village where the trainees live, they are distracted by their other activities and usually come late. This is not the case when training is done elsewhere. However, the training venue should be easily accessible for the trainees.

## Duration of training

The recommended training duration is 3–5 days depending on the needs of the trainees.

## Creating learning conditions

The trainer should start with creating the learning conditions. This is mostly done at the beginning of the training. These conditions can be used to adjust the training to the level and expectations of the trainees:

1. The trainer should learn about the trainees: age, background, education, experience and their expectations.
2. What is the level of reading and writing skills? This can be observed in exercises or group activities.
3. The trainer should know what the learning objectives of the trainees are and what the trainees expect to learn.
4. The training should include means for trainees to practice skills and techniques.

The trainer should also provide suitable training facilities and equipment and provide training materials (presentations, guidelines, etc.).

## Change of mind-set, awareness and attitude

It is important that smallholders have the right mind-set and attitude to engage in aquaculture. A training course is a good way to have an impact on the awareness of farmers. Emphasis should be given that only with the right attitude an aquaculture farm will succeed.

## Training plan

This training manual consists of different modules that are broken down in topics. For each topic the trainer should follow the following method to make a training plan:

- Define topics to be covered: The topics are outlined in this manual. However, the trainer may adjust the topics covered according to the trainees and the time available.
- Define the learning objectives: What should the trainee be able to do after the topic has been discussed?
- Find out what the trainees already know about the topics.
- Determine what the trainees should know and what skills they need.
- Build on the trainees' knowledge and skills.
- Provide necessary equipment and tools: Prepare handouts, materials needed for exercises. Exercises are included in this training manual. However, the trainer should decide which exercises to carry out. They may also add additional practical training or exercises.
- Explain background of each topic: Each topic in this training manual starts with a brief introduction about the topic and each BMP has an explanation. These should be shared with the trainees.
- Determine tasks: In this course it is mainly to understand why the BMPs should be implemented, how they can be implemented, farm methods and to be able to determine what is done incorrectly and how to improve it.
- Continually assess and evaluate each trainee's progress

## Teaching skills

It is important that the trainer has the necessary practical and technical knowledge and is familiar with the latest technologies in aquaculture. The trainer needs to be well prepared, flexible and have good communication skills. It is also important that the trainer knows the local language. If necessary, a trainer can improve their knowledge and skills by getting trained.

During the training the trainer should do the following:



Be respectful to all others



Observe traditions and norms



Maintain a gentle manner and impartiality



Give priority to comments made by others and encourage discussions



Ensure participation from all trainees (especially women and youths)



Listen well



Address trainees by name where possible



Be patient and understanding



Be honest when something is not known



Be careful about sensitive issues



Nonverbal communication should match verbal communication

## Evaluation of progress of trainees

The trainer should assess the performance of the trainees. It is important that the training is effective and useful for the trainees. If results are unsatisfactory, the trainer should consider adjusting the training. Evaluation and performance reviews can be used for this. Performance can be assessed by observation of the trainee, i.e. performing a task, or through questions and answers, discussions or exams. The trainer should also provide feedback to the trainees when necessary to increase the trainees' learning experience.

The trainer should not assess the trainees only at the end; it should be done regularly to assess problems. Problems can indicate weaknesses of the course or trainer. If exams/tests are used for assessment these should be relevant, objective and reliable. Results of the progress will indicate if what the trainee learned is appropriate for their work, if they face problems for which they have not been trained, and if the trainees work with interest and satisfaction.

A sample of an evaluation and test form can be found in Appendix 2.

### Tips for trainers:

- Training should be followed up
- Improve knowledge of trainers: trainers need training
- Train more trainers
- Seed and feed should not be provided for free (to encourage sense of ownership).

## Training materials

The trainer needs to arrange the training materials that serve as tools for the training. For the theory training the trainer can use a black or whiteboard, flipcharts or a PowerPoint presentation if the facilities are available. Trainees appreciate receiving some reference materials that they can use after the training. For practical training, the trainer should prepare the necessary materials too. Trainers should not use this training manual as handouts or share the content with the trainees directly. Training materials appropriate to the level of the smallholders should be developed by the trainer.



## How to make a good PowerPoint presentation?

- Keep the slides simple: The presentation should support your training, not be the focus of attention. There is no need to fill up empty space.
- Limit bullet points and text: The slides should benefit but not bore the audience. The message should be delivered by the trainer not by the presentation. The best slides may not have text at all. You can give a detailed handout to the trainees after the training for their reference.
- Limit the number of slides: A good rule of thumb is one slide per minute.
- Limit animation: Some animation is good, but this should be limited and subtle.
- Use high quality graphics: Avoid using clip-art and do not stretch low resolution photos. Use images to get your point across. Images are processed much faster than text.
- Use a visual theme: Use a constant background in your slides. Use contrast in colors for text and background.
- Use the same font set throughout the presentation.
- Use videos: Videos can show concrete examples and promote natural learning.
- Do not read from your slide; face the audience, not the screen. Ensure that all trainees can hear you loud and clear.

See Appendix 4 for an example set of PowerPoint slides.

### Tips for handouts/reference material

- Should be in both English and local language
- Should be concise and clear
- Mainly illustrations and pictures should be used to explain BMPs.

## Certificate

After the training you may opt to provide a certificate to each participant.



Certification after a training session at Mukasa Agrosolutions Agro dealers.

# References

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- Bbole I, Katongo C, Deines AM, Shumba O and Lodge DM. 2014. Hybridization between nonindigenous *Oreochromis niloticus* L. and native *Oreochromis* species in the lower Kafue River and its potential impacts on the fishery. *Journal of Ecology and Natural Environment* 6(6):215–25.
- Booth AJ, Merron GS and Colin D. Buxton CD. 1995. The growth of *Oreochromis andersonii* (Pisces: Cichlidae) from the Okavango Delta, Botswana, and a comparison of the scale and otolith methods of ageing. *Environmental Biology of Fishes* 43(2):171–78.
- [CSO] Central Statistical Office. 2014. Labour force survey report. Lusaka, Zambia: CSO.
- Cullar-Anjel J, Lara C, Morales V, De Gracia A and Garcia. 2015. Manual of best management practices for *Penaeus vannamei* farming.
- Genschick S, Kaminski AM, Kefi AS and Cole SM. 2017. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems; Lusaka, Zambia: Department of Fisheries. Working Paper: FISH-2017-08.
- Hollingsworth CS, Baldwin R, Wilda K, Ellis R and Soares S. 2006. Best management practices for finfish aquaculture in Massachusetts. University of Massachusetts Extension.
- Kaminski AM, Genschick S, Kefi AS and Kruijssen F. 2017. Commercialization and upgrading in the aquaculture value chain in Zambia. *Aquaculture* doi.org/10.1016/j.aquaculture.2017.12.010
- Isyagi NA, Veverica KL, Asimwe R and Daniels WH. 2009. Manual for the commercial pond production of the African catfish in Uganda. Department of Fisheries and Allied Aquacultures. Auburn University, Alabama, USA.
- Mudenda HG. 2009. Assessment of national aquaculture policies and programs in Zambia. SARNISSA.
- [NRC] National Research Council. 1993. Nutrient requirements of fish. Washington, D.C.: National Academy Press.
- Namonje-Kapembwa T and Samboko P. 2017. Assessing the profitability of small-scale aquaculture fish production in Zambia. Indaba Agricultural Policy Research Institute. Working Paper 123.
- Negrone G. 2013. Tilapia farming guide NPH Haiti/Fondazione Rava II Revision.
- Philippart JCL and Ruwet JCL. 1982. Ecology and distribution of tilapias. In *The biology and culture of tilapias*. Pullin RSV and Lowe-McConnell RH, eds. International Centre for Living Aquatic Resources Management conference proceedings 7:15–60.
- Shula AK and Mukuka RM. 2015. The fisheries sector in Zambia: Status, management, and challenges.
- Sneyers G and Ingawa SA. 2005. Fish pond construction and management (a field guide and extension manual). Rome: FAO.
- Yadav CNR. 2006. Tilapia: An introduction and culture potentiality in Nepal. *Our Nature* 4:107–10

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# Appendix 1. Private sector contact list

Organization	Main activity	Contact
<b>Feed suppliers</b>		
HORIZON/Aller Aqua	Producing high quality compound fish feed for pond culture, as well as "feed" with low protein content to be used as pond fertilizer	Mr. Lewis Ngwenya ln@aller-aqua.co.zm +260 968829425 www.aller-aqua.co.zm
Novatek	<ul style="list-style-type: none"> <li>• Feed supply</li> <li>• Extension and consultancy about proper feed and fertilization management</li> </ul>	Mr. Kanyembo Aquaculture consultant 0971252522 www.zambeefplc.com
Skretting	Feed supply and extension	(+260) 976258187 sales.zambia@skretting.com www.skretting.com
Olympic Milling Ltd Farm feeds	Feed supply	Mr. Clinton +260 971778393
<b>Equipment supplies</b>		
Savanna Streams	<ul style="list-style-type: none"> <li>• Nets, cages, fingerlings, liners, feed retailers</li> <li>• Provides training and technical advice</li> </ul>	+260 955555095 www.savannabiz.com
Ketchline	Nets, cages	+260 977875147
Firsthatch	Liners, nets, fingerlings	Mr. Bright Mutele +260 977923425 Brightfieldm@gmail.com
<b>Fingerling supplies</b>		
Msekese fisheries	<i>O. andersonii</i> fingerlings	Farm 4300, Kafue Road, Lilayi, Lusaka +260 964994353
Palabana	Fingerling sales, pond liners	F380a/B/15 off Palabana Road, Lusaka +260 977822030 www.palabanafisheries.com
Mukasa Fish farm	<i>O. andersonii</i> fingerlings	Mr. Royd Mukonda +260 978979035 mukondaroyd@gmail.com
<b>Fresh fish sales</b>		
Yalelo	Fingerling sales, out-grower and wholesaler, retailer of Nile tilapia	+260 211246060 www.yalelo.com
Capital fisheries	Wholesalers of fish and seafood	Plot No. 9065 Katanga Road, Lusaka +260 969111775
Kafue fisheries	Out-grower and wholesaler	
Lake Harvest	Out-grower and wholesaler of Nile tilapia	Plot 7228 Kachidza Road, Plot No. 33325, Lusaka +260 965078215
Mpende fisheries	Fingerlings sales, out-grower and wholesaler of Tanganyika bream	Plot 3710M, Lake Tanganyika, Nsumbu, Northern Province www.mpendefisheries.com admin@mpendefisheries.com



## Appendix 2. Evaluation and test form

# Better management practices for tilapia smallholders in Zambia

## Evaluation Form

1. Are you a man or a woman?

Man ( ) Woman ( )

2. Are you currently a fish farmer?

Yes ( ) No ( )

3. How useful did you find each topic?

### Farm preparation

1 2 3 4 5

• Species selection

• Site selection

• Pond construction and preparation

• Biosecurity

### Farm operations

1 2 3 4 5

• Stocking

• Nursery

• Feeding

• Fertilization and supplementary feeds

• Water quality

• Fish health

### Postharvest management

1 2 3 4 5

• Harvesting

• Handling and transport

• Marketing

**Business**

	1	2	3	4	5
• Business planning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Production planning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Finances	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Record keeping	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Clusters	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Which topics were most important for you?

---

---

---

5. Which topics were the least important?

---

---

---

6. Was there a topic missing?

---

---

---

7. How did you find the following?

	1	2	3	4	5
• Lectures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Practical training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Exercises	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Group discussions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Relationship between trainer and trainees	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. How can we improve the training?

---

---

---

# Better management practices for tilapia smallholders in Zambia

## Test Form

This is an exam to test your learning experience from the BMP training course.

**Instructions:** The questions in the following sections are short answer questions. They are of two types:

**Section A:** These are true or false questions. Indicate whether the statement is True or False (circle your choice).

**Section B:** These are multiple-choice questions (circle the correct answer).

Each question contains one correct answer only.

Name: \_\_\_\_\_

Designation: \_\_\_\_\_

Score: \_\_\_\_\_

### Section A: Indicate which statements are true or false (circle your choice).

A1	Better management practice have been developed to increase profitability of the farm and reduce environmental impacts.	True ( ) False ( )
A2	Species should be selected based only on the market price.	True ( ) False ( )
A3	Sandy soils are the best for pond construction.	True ( ) False ( )
A4	Each pond should have its own inlet.	True ( ) False ( )
A5	Pests and predators pose a risk for pond aquaculture.	True ( ) False ( )
A6	The quality of seed is not important as long as the size is large enough.	True ( ) False ( )
A7	Seed should be acclimatized to the conditions in the pond before stocking.	True ( ) False ( )
A8	Using hapas to grow fry before stocking in the pond will increase survival rate.	True ( ) False ( )
A9	Farm-made feed provides a balanced diet to the fish.	True ( ) False ( )
A10	Commercial fish feeds should be stored in a warm and moist area to prevent spoilage, mold growth and contamination.	True ( ) False ( )
A11	If water is dark green, no fertilizer should be added.	True ( ) False ( )

A12	When fish are gasping at the water, this is a sign that there is enough oxygen in the water.	True ( ) False ( )
A13	Fish should be observed regularly for symptoms of disease.	True ( ) False ( )
A14	Agreements should be made with the buyer before harvesting the fish.	True ( ) False ( )
A15	Harvesting of aquaculture products should be conducted in a way that minimizes physical damage.	True ( ) False ( )

**Section B: Circle the correct answer (or follow the specific instruction of the question).**

- B1. Why should we use native species?
- To follow the regulations of the DOF
  - To avoid introduction of exotic species to the environment
  - Both a and b
- B2. What is the most important factor when selecting a site?
- Land should be steep
  - The availability of a constant supply of clean water

- c. That the site is a dambo area
- B3. What kind of seed will give the best production?
- a. All female seed
  - b. All male seed
  - c. Mixed sex seed
- B4. What factors should be taken into account when feeding?
- a. Feeding times
  - b. The pellet size
  - c. The quantity of feed
  - d. All of the above
- B5. What can a farmer do to prevent disease into a farm?
- a. Allow visitors on the farm
  - b. Wear old clothes
  - c. Wash their hands before work and after going to the toilet or eating
- B6. What is an advantage of being part of a farmers cluster?
- a. Farm inputs can be bought together
  - b. All farmers can negotiate their sales with buyer separately
  - c. Farmers can buy more seed
- B7. Which water quality reading is a cause for concern?
- a. DO of 2.5
  - b. Temperature of 30°C
  - c. pH of 6.5
  - d. All of the above
- B8. What are the most important records a farmer should keep?
- a. Stocking, mortalities, feed amount and type and finances
  - b. Water quality, Feed management and cleaning records
  - c. Stocking, cleaning records, and training records
- B9. What can a farmer do to ensure healthy fish?
- a. Regular sampling
  - b. Maintain good water quality
  - c. Both a and b
  - d. Neither
- B10. How can farmers ensure sales of their fish?
- a. Sell fish that is market size and high quality
  - b. Harvest the fish before a buyer is identified
  - c. Sell the fish when they are small



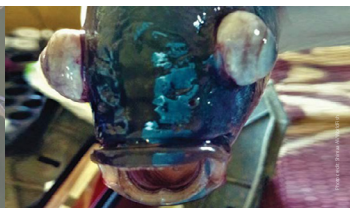
# Appendix 3. Tilapia major clinical signs

## Tilapia major clinical signs

The purpose of this poster is to enhance the capacity of hatcheries, nurseries, grow-out farmers and extension service providers to recognize and report tilapia diseases. Prevention, early recognition, diagnosis and rapid intervention are the best steps to manage aquatic animal diseases. If you observe clinical signs, abnormal behaviour and unusual mortality, contact your local aquaculture health professionals to report and ask for support.



Fish lethargic at surface and not feeding



Eye exophthalmia/popeye



Eye endophthalmia/eye shrinkage



Eye opacification



Skin erosions hemorrhagic lesion



Skin discoloration



Open wounds



Abdominal distension/swelling



Scale protrusion/detachment



Fish gasping air at the surface



Gill paleness (anemia)



Gill rot



Fin rot/tail rot



Swollen anus

This tilapia disease extension material and photographs were developed by the CGIAR Research Program on Fish Agri-Food Systems (FISH) led by WorldFish. It was produced as part of the WorldFish better management practice (BMP) resources to support sustainable and responsible tilapia farming.

# Appendix 4. Sample PowerPoint presentation




Slide 1

## FARM OPERATIONS

### Feeding

**BMP1: Feed should be purchased from a reputable manufacturer**

- Buy quality commercial feeds
- Buy directly from feed mill or dealer
- Floating pellets are recommended


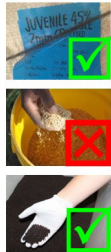


Slide 2

## Feeding

**BMP2: Only fresh, high quality feed should be used**

- Growth rate, survival and health depend on feed quality
- Check labels of feed (should include expiry date and ingredients)
- Labels can also have instructions and guidance
- Check content before feeding (dry and free of mould)
- Use feed prior to the expiry date



Slide 3

## Feeding

### BMP3: Use the correct feed size

- Feed pellet size appropriate for size of fish
- Ask feed supplier for guidance
- Observe feeding behaviour



Slide 4

## Feeding

### BMP4: Feed consistently and regularly

- Feed at the same times every day
- Adapt feeding frequency to fish size
- Feeding amount should not exceed daily feeding rate

Body weight of fish (g)	Feeding rate (% body weight)	Number of times feeds per day
1-5	6-10	5-6
5-25	5	4
25-150	3	3
>150	2	2



Slide 5

## Feeding

### BMP5: Use feeding methods that reduce stress and environmental impact

- Follow instructions of feed supplier
- Do not overfeed (will decrease water quality)
- Floating hose pipes or rings can be used to contain floating feeds in one place



Slide 6

## Feeding

### **BMP6: Feeding the right amounts of feed**

- Adjust feeding rates to fish behaviour
- Do not overfeed or underfeed
- Sample fish to calculate feeding quantities
- Or feed to satiation (using floating feeds)



WorldFish

Slide 7

## Feeding

### **BMP7: Feed should be stored in a cool, dry and pest proof area**

- Feed storage should be cool and dry
- Feed storage should be protected from pest entering
- Feed should be elevated from the ground (using wooden pallets)
- Open one bag at the time
- Wet, expired or moldy feed should be discarded

WorldFish

Slide 8

## Feeding

### **BMP7: Feed should be stored in a cool, dry and pest proof area**



WorldFish

Slide 9



## Feeding

### Exercise: Calculating feed amount

Explanation	Calculation
Data from your records	Average body weight sampling of fish: 82g Number of fish: 800 Pieces
Total weight of fish in the pond: Weight x number of fish	$82\text{g} \times 800 \text{ pieces} = 65,600 \text{ g} / 1,000 = 65.6 \text{ Kg}$
Total amount to feed daily to your fish: Weight of fish in the pond x daily feeding rate	$3.0\% = 0.03$ $65.6 \text{ Kg} \times 0.03 = 1.968\text{Kg} \approx 2.0 \text{ Kg}$
Feeding portions (for this example 2 portions):	Morning feed: $2.0 / 2 = 1 \text{ Kg}$ Afternoon feed: $2.0 / 2 = 1\text{Kg}$



### Slide 10

## Feeding - Exercise

### Exercise: Calculating feed amount

**Ms. Tabitha has 1,000 fish in her pond. Today she sampled 20 pieces of fish and the average weight was 105 grams.**

- 1) How much is the total biomass (kg) in the pond?
- 2) How much feed should she give to her fish per day?  
*Tabitha feeds her fish three times per day.*
- 3) How much feed should she use for each feeding?



### Slide 11

## Feeding - Exercise

### Discussion: FCR

The FCR is the amount of food required to produce one kg of fish. It is an indicator for performance of the feed, efficiency of the response to feeding and cost-effectiveness of the feed. An FCR of 1.6 means that by feeding 1.6Kg of feed you produce 1 Kg of fish.

It is calculated as following:

$\text{FCR} = \text{Total amount of feed given (kg)} / \text{Total amount of fish produced (kg)}$

*Why is it important to know the FCR?*



### Slide 12

## Thank You



This work was undertaken as part of



Funded by



In partnership with



### Slide 13





RESEARCH  
PROGRAM ON  
Fish

Led by WorldFish

## About FISH

The CGIAR Research Program on Fish Agri-Food Systems (FISH) is a multidisciplinary research program. Designed in collaboration with research partners, beneficiaries and stakeholders, FISH develops and implements research innovations that optimize the individual and joint contributions of aquaculture and small-scale fisheries to reducing poverty, improving food and nutrition security and sustaining the underlying natural resources and ecosystems services upon which both depend. The program is led by WorldFish, a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

For more information, please visit [fish.cgiar.org](http://fish.cgiar.org)