FARMERS' MANUAL ON SMALL-SCALE TILAPIA POND FARMING IN GHANA

Prepared by:

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FOREWORD

This manual provides a comprehensive step-by-step guide to pond aquaculture. It includes tips on site selection, site preparation, pond design and construction, farming practices (pond preparation, stocking, and feeding), biosecurity and fish health management, harvesting and marketing and recordkeeping – all of which are critical elements of a successful tilapia pond aqua-farming business operation.

Aquaculture has existed in Ghana since the 1950s, though the sector didn't experience major growth until around 2000, when large-scale commercial production began. Today, it plays a key role in the nation's prosperity, contributing to food security by augmenting domestic fish production and creating jobs.

Even so, challenges that have historically plagued the sector and hindered growth remain pervasive. These include low technical know-how and a lack of quality inputs such as seed and feed. Although knowledge in the sector has increased over the years, small-scale farmers (most of whom are indigenous) continue to struggle with basic farming practices. As a result, they're often faced with poor yields, which can ultimately lead to a farm's collapse.

The Tilapia Seed Project is aimed at accelerating quality tilapia seed production and dissemination in Ghana. Project stakeholders produced this manual to provide accurate direction to small-scale fish farmers in Ghana. After reviewing its contents, we expect that it will prove instrumental in helping farmers improve production, and that it will serve as a valuable catalyst for growth in this important sector.

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PREPARATION OF THIS MANUAL

This manual was compiled by researchers (Seth K. Agyakwah, Ruby Asmah, Emmanuel T.D. Mensah, Catherine Ragasa, Sena Amewu, Nhuong Tran) and Fisheries and Aquaculture sector policy regulators (Mathew Oyih, Peter Ziddah), working on the Tilapia Seed Project (*Accelerating aquaculture development in Ghana through sustainable Nile Tilapia seed production and dissemination*), which was funded by the NWO-WOTRO (The Netherlands) and the CGIAR Research Programs on Policies, Institutions and Markets (PIM) and Fish Agri-food Systems (FISH). Some of the information included here was adapted from the following manuals: *Handbook on Fish Farming* (from the FAO Training Series); a hands-on training handout on small-scale pond and tank fish farming distributed by CSIR-WRI-ARDEC; and selected WorldFish project documents and training manuals.

This manual was reviewed by the following aquaculture experts: Dr. Kofi Abban (retired Chief Research Scientist-Fish Geneticist, CSIR-WRI), Mr. Lionel Awity (former Aquaculture Specialist, FAO Africa Regional Office and former Director-Aquaculture and Inland Fisheries, Fisheries Commission, Ghana), Dr. Winnie Sowah (Fish Geneticist, University of Ghana), Mrs. Janet Anchirina (Asuogyaman Zonal Fisheries Director), Mr. Opoku Gyinae (retired Fisheries Officer and private farmer), Ms. Patricia Safo (Director, Crystal Lake Fish Limited), Mr. Godfred Alimo (Manager, S-Hoint Limited), Bright Addo (BritAddo Farms) and Mrs. Florence Danso (Flosell Farms Ltd.).

This manual is a living document that will be updated for the duration of the project. It has not undergone a formal peer-review process through IFPRI or WorldFish. Any opinions stated herein are those of the author(s) and are not necessarily representative of or endorsed by IFPRI, WorldFish, PIM, or CGIAR.

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CHAPTER 1 INTRODUCTION TO POND FISH FARMING

1.1 What is fish farming?

Fish farming is the growing of fish for profit or for personal use.

1.2 Importance of fish farming

i. For income generation
ii. For employment/job creation
iii. To satisfy nutritional needs
iv. For food security and health
v. To supplement dwindling production of capture fisheries
vi. For trade (local/global)
vii. To enhance use and benefits from land and water resources

1.3 Planning a pond fish farm

In order to begin farming, you should:

i. Identify a site or a piece of land on which to build your pond. The land or site should not be earmarked for another activity;
ii. Make sure you have a reliable source of water (lake, river, underground water, stream or rainfall, where it is reliable (perennial));
iii. Develop basic fish farming skills;
iv. Speak to a Fishery Officer or an Extension Agent for technical advice, if necessary;
v. Develop a farm layout/site plan;
vi. Obtain inputs such as fingerlings, feeds, fertilizer for your ponds, lime to treat your pond;
vii. Obtain access to farming equipment such as scales, boats, water quality kits, bowls, scoop nets, feeding kits and graders, as well as facilities such as a farmhouse and feed storage room;
viii. Find buyers who will purchase your fish when you are ready to sell;
ix. Make sure you have a reliable source of capital;
x. Develop a business plan;
xi. Obtain relevant permits, where applicable (Environmental Permit, Water Resources Commission permit, Fisheries Commission permit – for large-scale (> 1000 tonnes per year) operations).

Generally, the quantity of fish you want to grow commercially will depend on:

i. The size of the market (how much fish customers will buy from you in a period (e.g., one year));
ii. The amount of suitable land that is available;
iii. The annual availability of good quality water;
iv. The type of farming practice you want to adopt;
v. The availability of capital (money) for the aquaculture business.

1.4 Know your fish

There are different kinds of freshwater fish species for culture. Before deciding to culture a particular species of fish, consider its:

i. Growth rate;
ii. Reproductive behavior;
iii. Nutritional requirements;
iv. Market value;
v. Ability to withstand varied environmental conditions;

vi. Ability to survive in an artificial environment.

Additionally, you'll want to consider other factors such as:

vii. Social acceptability/cultural issues related to the fish species;
viii. Aquaculture technology development and research support;
ix. National regulations and policy direction.

In Ghana, there are primarily 3 species used for pond farming: Nile tilapia, *Oreochromis niloticus*, Bonny tongue, *Heterotis niloticus*, and African catfish, *Clarias gariepinus* (Plate 1-1). Nile tilapia accounts for almost 90% of species cultured. This species is relatively easy to culture, grows faster and has the ability to withstand and grow in harsh environmental conditions.

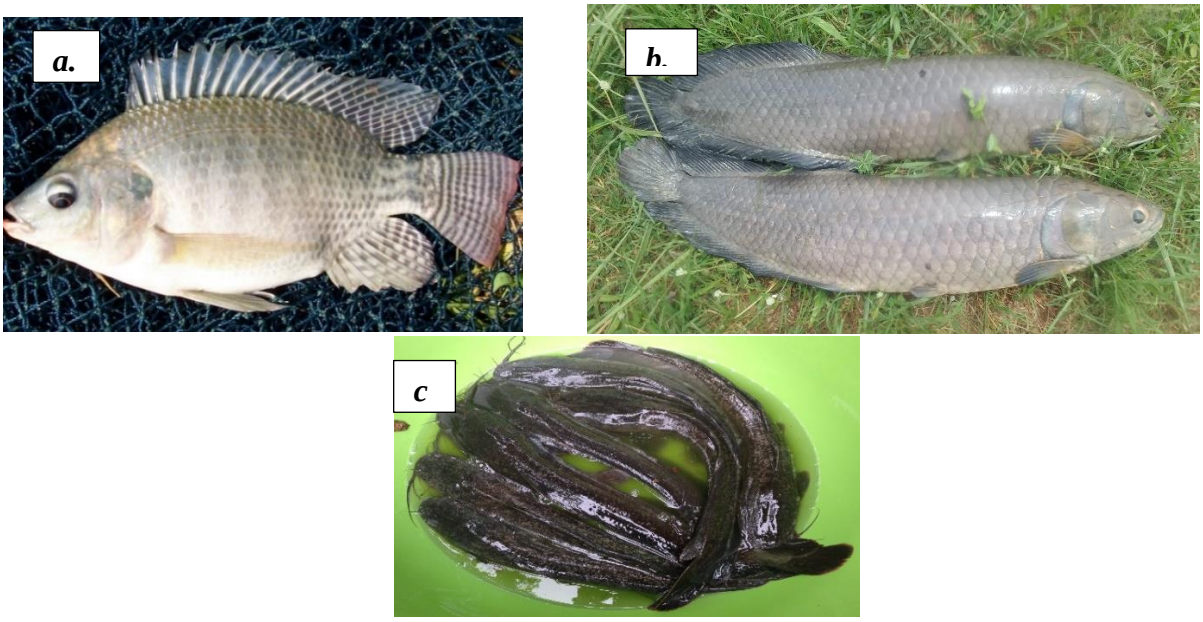

Plate 1-1: Different species for culture: a. Nile tilapia, b. Bonny tongue, c. African catfish

1.5 Permits for aquaculture operations

There are national laws, regulations and policies governing aquaculture production in Ghana (Fisheries Act 625, 2002; Fisheries Regulations, 2010). (A copy could be obtained at the following web address - http://extwprlegs1.fao.org/docs/pdf/gha151991.pdf). These permit the use of local species for culture and ban the import of fish for culture.

Before starting your operation, obtain an Environmental permit from the Environmental Protection Agency (EPA), water usage rights from the Water Resources Commission (WRC) and an Aquaculture permit from the Fisheries Commission (FC).

CHAPTER 2 SELECTING A SUITABLE SITE FOR YOUR FARM

2.1 Factors to consider in site selection

The success of an aquaculture operation largely depends on the proper selection of the site to be developed. Factors to consider when selecting a site include land, soil type and water as well as economic and social factors.

A number of problems could arise if you do not choose a good place for your farm.

i. Your pond may not hold water for long enough to raise fish
ii. Ponds may flood, causing fish to escape or unwanted fish to enter
iii. Pond walls may collapse if soil type is not good
iv. Ponds may not drain completely
v. Harvesting fish may be difficult
vi. Your water source might be poor, causing fish to die or not grow well
vii. Your pond may not produce enough live food for the fish
viii. Your pond may be inaccessible, creating logistical challenges
ix. Yields may be poor, leading to reduced profits

2.1.1 Land

Consult with an aquaculture expert or Extension Officer to verify that the proposed site is suitable for production. Consider the factors below.

i. Slope of land and pond design
   a. Sloping land has shallow soil; flat land usually has deep soil
   b. Land with a steeper slope holds fewer and smaller ponds
   c. The pond bottom must have sufficient slope for good drainage
   d. If the slope is too gentle, the pond will not be easily drained
   e. If the slope is too steep, it may be too shallow at one end or too deep at the other end
   f. In general, flat land with a gentle slope is most suitable for pond construction
ii. The number and sizes of ponds to be constructed
iii. Availability of good quality water sources
iv. Amount of water needed for each pond in your farm
v. Climate and rainfall patterns
vi. Environment - do not locate your farm in a wetland or flood plain of a river
vii. Other users - there should be peace and order among all users of the water source
viii. Proximity to customers and farm workers

2.1.2 Soil Types

i. Soils are made up of a mixture of living organisms, organic particles (decayed plant and animal materials), mineral particles (such as sand, clay, stones or gravels which have been broken down from larger rocks), water and air.
ii. Soils are generally classified as **clay, silt or sand**. Clay soils do not allow water to pass through easily. Sandy soils allow water to pass through easily.
iii. Soils that consist of too much sand or clay are not suitable for pond construction.
iv. Topsoil is high in organic material and should not be used to construct pond dikes.
v. Soils with 20-35% clay are the best for building ponds.
vi. Use soils with a high percentage of clay (30-35% or more) to build pond dikes and trenches.

2.2 How to choose the right soil for constructing good ponds

Soil composition may vary within a given area. You should therefore test the soil at many places within the area of land.

i. First, clear weeds and tree stumps from the land.
ii. Measure and peg the corners of the area designated for pond construction.
iii. Divide the area into 4 to 8 parts, depending on its size.
iv. In each of these parts, test the soil in one or all of the ways shown below (Figure 2-1 to Figure 2-3).

The dig-and-fill test

Plate 2-1: Permeability test of the soil (Dig-and-fill test)
(Source: FAO, 1981)

Squeeze-the-ball test

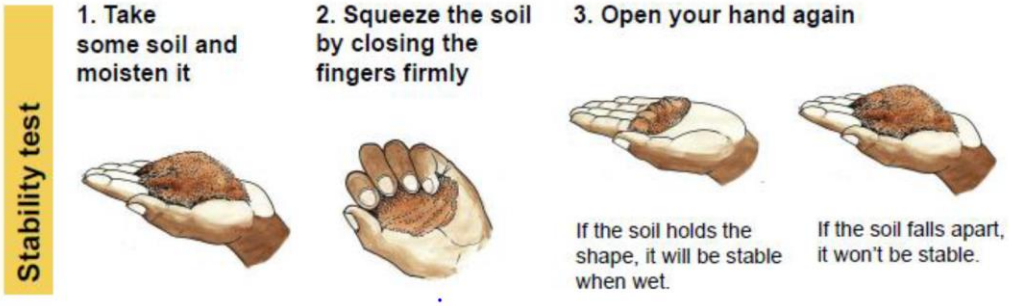

Figure 2-1: Squeeze-the-ball test of the soil
(Source: FAO, 1984)

Rub-the-soil test

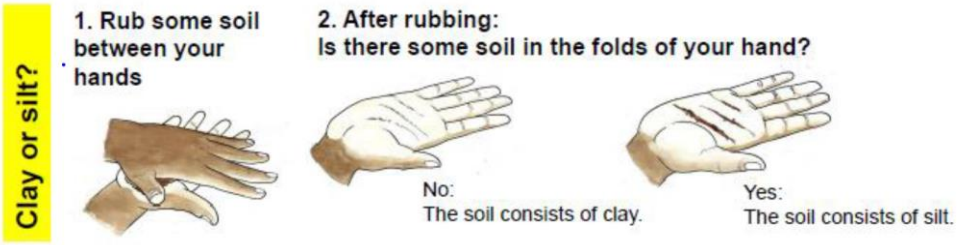

Figure 2-2: Checking if water will pass through the soil
(Source: FAO, 1984)

The mud-ball test

To check soil composition, follow the steps below:

a. Take a handful of moist soil and squeeze it into a ball;
b. Throw the ball into the air about 100 cm (arm length) and then catch it;
c. If the ball falls apart, it is poor soil with too much sand in it;
d. If the ball sticks together, it is good soil with enough clay in it.

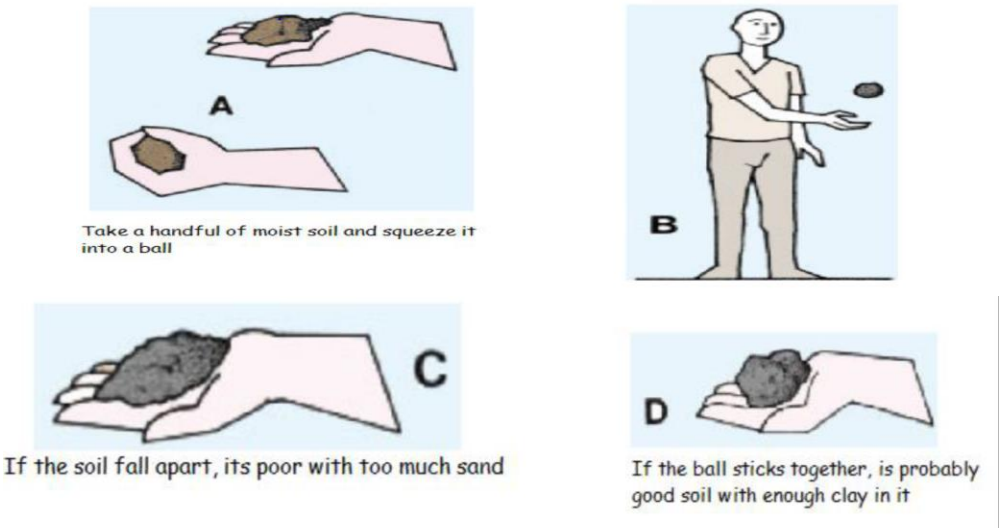

Figure 2-3: Test for texture of the soil
(Source: FAO, 2006)

2.3 Water supply

i. Your pond must be near a good, year-round supply of water such as a river, stream, lake or reservoir, underground water source or rainwater (Plate 2-2)
ii. Water should not smell or taste bad or be milky or brownish in color
iii. Water should not be too muddy water from a stream, lake or reservoir is usually good but it may have wild fish in it
iv. Cover the mouth of the inlet pipe with a mosquito to prevent wild fish from entering

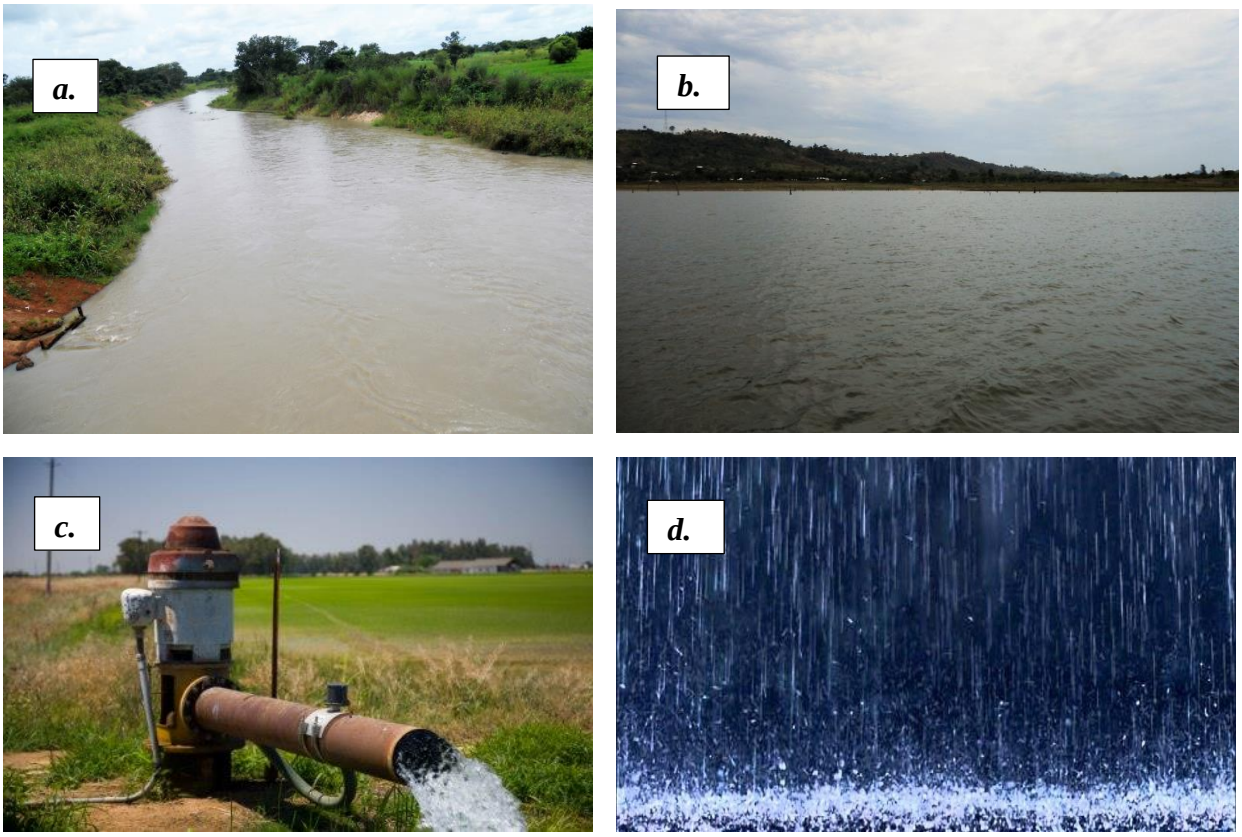

Plate 2-2: Different sources of water for culture: a. river, b. lake, c. underground water, d. rainwater

2.3.1 Advantages and disadvantages of water sources

The advantages and disadvantages of various water sources are stated in Table 2-1.

Table 2-1: Advantages and disadvantages of using these sources of water

Source	Advantages	Disadvantages
Springs	Constant temperature Few or no known pathogens	One must use pumping machines to pump the water onto the farm - this can increase your cost of production.
Wells (pumped or artesian)	No predators Pathogens hardly present	Tends to have high proportions of dissolved gases like carbon dioxide. Low in oxygen.
Rivers, lakes and streams, run-off or rain.	Large volumes of water Inexpensive	Easily contaminated, predators can easily come for fish. There could be high level of pollutants and suspended organic matter.
Groundwater	Inexpensive Few predators	Very difficult to drain, harvesting is difficult, and organic materials can build up very quickly.
Pipe-borne	Very high quality No predators or pathogens	Chlorine and other added disinfectants can be toxic to fish. It is expensive to use treated water for fish farming. It can be unreliable due to frequent shutdowns.

2.4 Economic and social factors

The following economic and social factors should be considered when selecting a pond site:

i. Quantity and quality of available manpower;
ii. Social and religious customs;
iii. Consumer habits;
iv. Availability and cost of construction materials and equipment;
v. Transportation, communication and other infrastructural (e.g., electricity, etc.) facilities;
vi. Security of tenure;
vii. Industrial and agricultural planning in the area;
viii. Accessibility and nearness to markets.

CHAPTER 3 POND DESIGN AND CONSTRUCTION

3.1 Types of ponds

Ponds are classified according to:

i. Mode of construction (barrage ponds, diversion ponds, sunken ponds)
ii. Materials used in construction (concrete, earthen, tarpaulin, polytank)
iii. Intended usage (nursery pond, grow-out pond, broodstock pond, quarantine pond, conditioning pond, sedimentation pond)
iv. Drainability (drainable or undrainable)

There are several pond types: barrage ponds, diversion ponds and sunken ponds (Figure 3-1).

- Barrage ponds are created in the bottom of a valley by building a dam across the lower end of the valley. The barrage pond is drainable through the old riverbed and directly fed from a nearby stream or reservoir. Water enters the pond at a point called the inlet and flows out at a point called the outlet. To protect the dike from floods, a spillway should be built.
- The diversion pond is fed indirectly by gravity or by pumping through a diversion canal, from a spring, stream, lake or reservoir. The water flow is controlled through a water intake. There is an inlet and an outlet for each pond. It is usually drainable through a drainage canal.
- Sunken ponds are the most common in Ghana. The pond floor is generally below the surface level of the surrounding land. The pond is directly fed by groundwater, rainfall and/or surface runoff. The sunken pond is undrainable or only partially drainable, since it's built either as a dug-out pond or to make use of an existing hollow or depression in the ground, sometimes with additional embankments to increase depth.

Ponds can also be made in different shapes and sizes. There is no recommended standard shape or size. Ponds can be rounded, rectangular or square, large, medium or small. Choose the shape and size that you feel most comfortable managing.

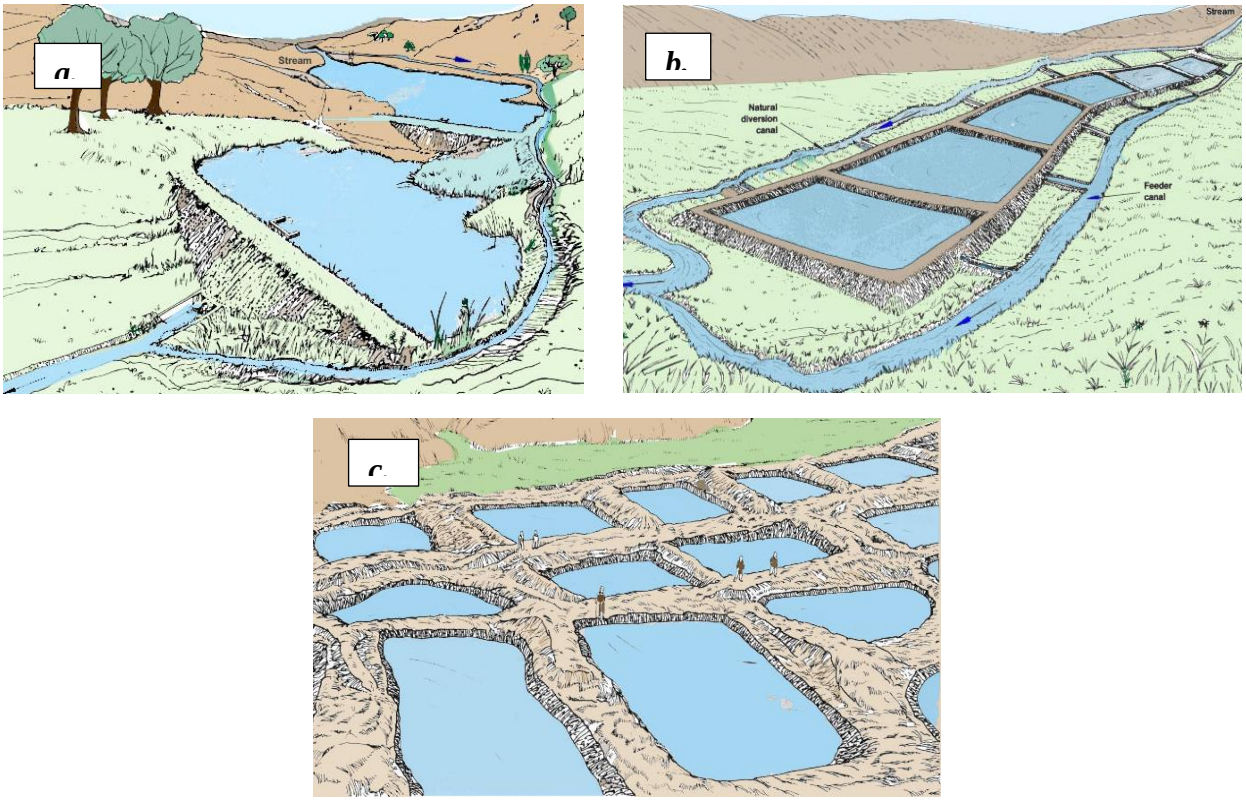

Figure 3-1: Different types of ponds: (a) barrage ponds, (b) diversion ponds, (c) sunken ponds
(Source: FAO Training Series, 2010)

3.2 Constructing your fishponds

3.2.1 Lining and pegging

a. Line and peg to set out the dimensions of your ponds (Figure 3-2)
b. Indicate the position of pond features (e.g., inlet and outlet points and the dike or pond wall)

***Pond size*:** The size of a prospective fishpond should be based on the purpose of the pond. Smaller ponds are easier to manage. A minimum size of 300 m^2 is recommended for small-scale commercial production.

***Shape*:** Rectangular ponds are usually the easiest to build and manage. However, ponds must sometimes be built with irregular shapes to fit the topography and shape of the available space.

***Depth*:**

i. The pond depth is usually in the range 1–2 m, depending on topography, water source and soil.
ii. 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.
iii. Ponds entirely dependent on seasonal rains must be deeper (i.e., 1.0–1.5 m) in order to hold water longer into the dry season.
iv. Maintaining the right depth of water helps to regulate temperature, inhibit growth of underwater plants and maintain dissolved oxygen (DO) levels at the pond bottom.

The slope of the pond bottom: The pond bottom must have a slope sufficient for good drainage. In general, slopes with a drop of 2 cm for every 10 m along the pond bottom are appropriate (Figure 3-3). If the slope

is too gentle, the pond will not be easily drained. If the slope is too steep, it may be too shallow at one end or too deep at the other end.

If your soil has a reasonable percentage of clay (20-30%), you can construct the dikes with 2:1 slopes (2 m horizontally for every 1 m vertically). If your soil has a low percentage of clay (20% or less), you should increase the dike slopes to 3:1 to prevent slumping and erosion of the pond banks.

3.2.2 The digging process

The construction approach you choose will depend on the nature of the land.

Digging from the deeper end allows you to:

i. Insert your outlet easily;
ii. Prevent flooding during construction;
iii. Set out the slope effectively.

The workers should start by digging all around the deeper end and using the excavated soil to form the dike.

Digging from the middle allows you to:

i. Spread the soil material evenly;
ii. Make construction less tedious.

The workers should be organized in a row with shovels and digging forks. The central 21 m x 11 m area is dug out first, and the excavated soil is used to build the dike (Figure 3-2). The digging begins at the shallow end of the pond, at the string marking the central area (Figure 3-3).

The pond is dug to about 20 cm deep at the shallow end, increasing gradually in depth towards the other end (Figure 3-4). At the deepest part, the string marking the central area should be about 30 cm deep. As the soil is dug out, it should be placed in the space marked out for the dike, between the 24 m x 14 m rectangle and the 30 m x 20 m rectangle.

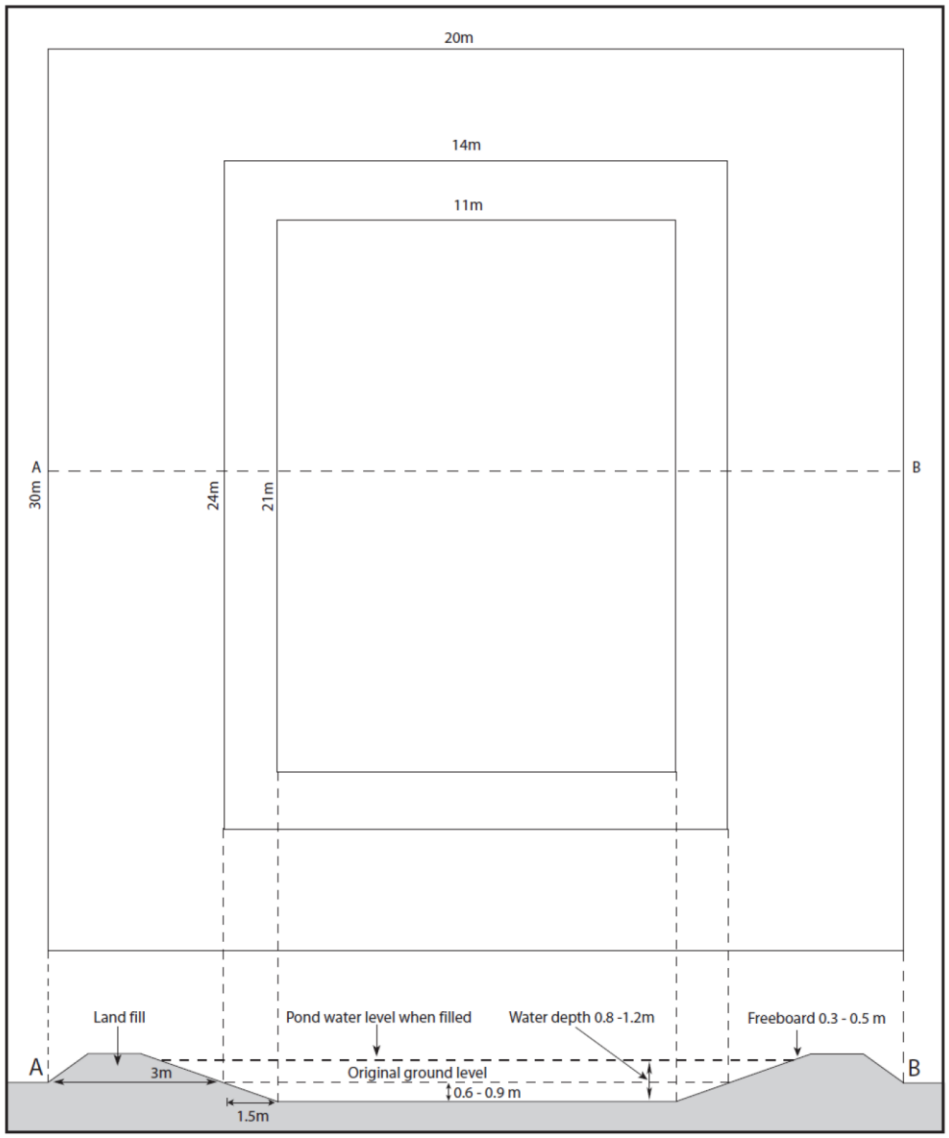

Figure 3-2: Ground plan for a hand-dug pond (top) and cross-section of pond along A-B (bottom)
(Source: Nandlal and Pickering, 2004)

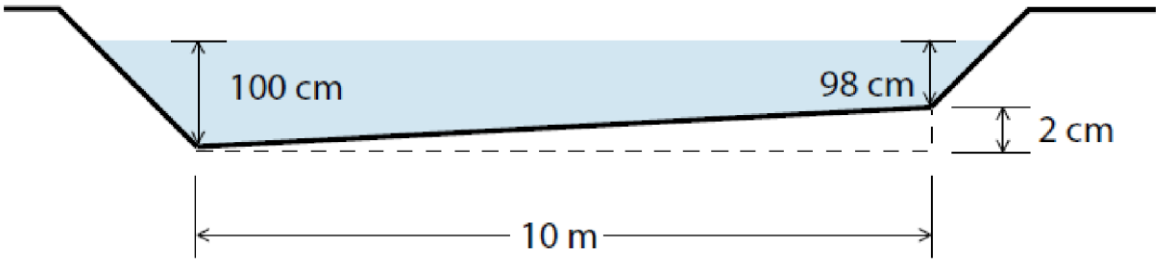

Figure 3-3: The sloping of the pond

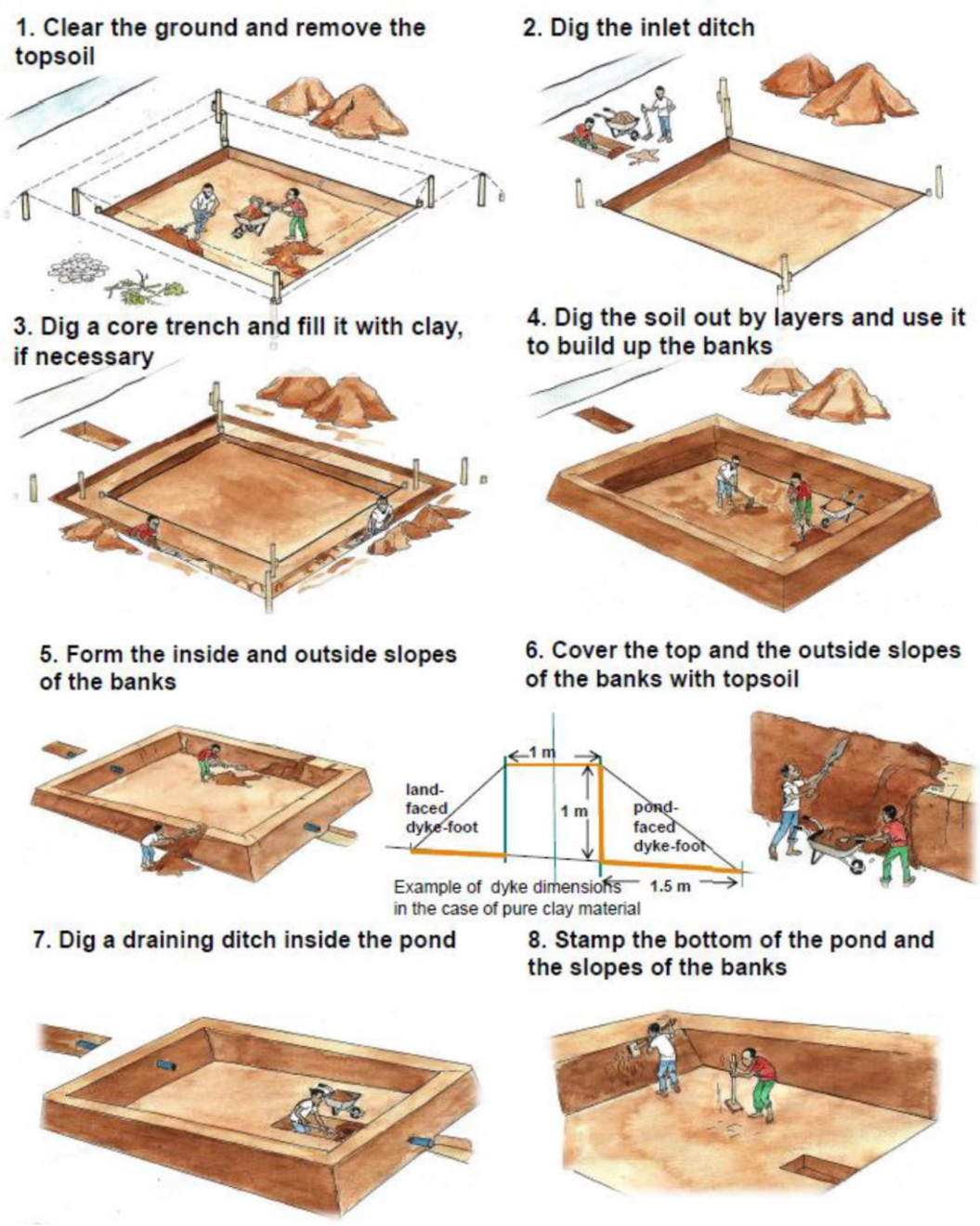

Figure 3-4: Digging your mapped-out pond
(FAO Training Series, 2010)

3.2.3 Installing your pond inlets

i. A water inlet is required to fill the pond with water.
ii. Place the inlet at a point nearest to the water source (Figure 3-5). This will usually be at or near the shallow end of the pond.
iii. An inlet pipe should be 25–50 mm (1–2 inches) in diameter, and long enough to reach across the dike from one side to the other.
iv. Once the position of the inlet is decided, dig a ditch across the dike.

v. This should be dug to a level that allows water to flow from the channel or pipe connecting the water source and the pond.
vi. The inlet pipe can be placed in the ditch in the dike, and the dike rebuilt over it.
vii. Alternatively, if an open channel is used to allow water into the pond, erosion of dike soil can be prevented by using roofing sheet or hard plastic to line the bottom of the channel.

3.2.4 Installing your pond outlet

i. The water outlet is made at the bottom of the dike at the deepest end of the pond (Figure 3-6Figure 3-5).
ii. The outlet is usually made from High Density Pressure Polyvinyl Pipes (pressure pipes) and should be at least 100 mm (3.94 inches) in diameter depending on the size of the pond (Table 3-1).

It is appropriate to dig a ditch through the area demarcated for the outlet before the dike is built.
It should reach from the deepest part on the inside of the pond through the dike to a lower level outside of the pond, to allow water to drain from the pond.

If the outlet is below ground level on the outside of the pond, it will be necessary to dig a drain to take the water away from the outlet.

Table 3-1: Sizes of outlet pipes for ponds with monks

Pond Size (m^2)	**Inside Diameter of Pipe (cm)**
< 200	Not less than 10
200 – 400	10 – 15
400 – 1,000	15 – 20
1,000 – 2,000	20 – 25
2,000 – 5,000	25 – 30
> 5,000	40 or more

Source: FAO, 2002

3.2.5 Screening pond inlets and outlets

Screens must be placed on the inlet (Figure 3-5), outlet and overflow pipes to prevent fish from escaping from the pond and to stop other fish and unwanted organisms from entering the pond (Figure 3-6).

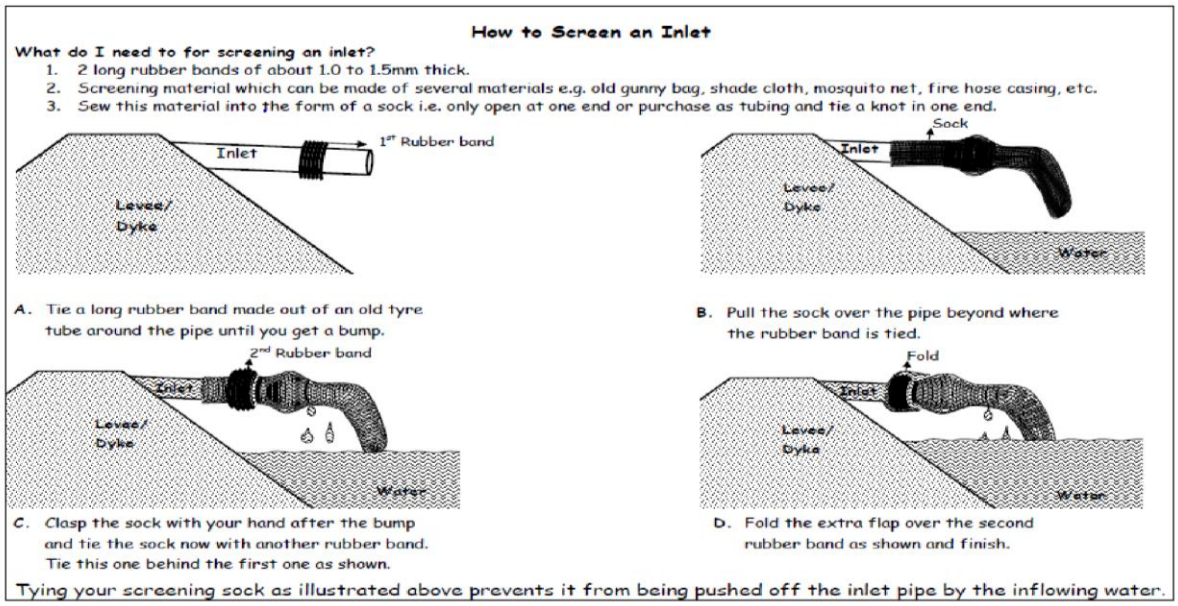

Figure 3-5: How to Screen the Inlet Pipe
(Source: Isyagi et al., 2009)

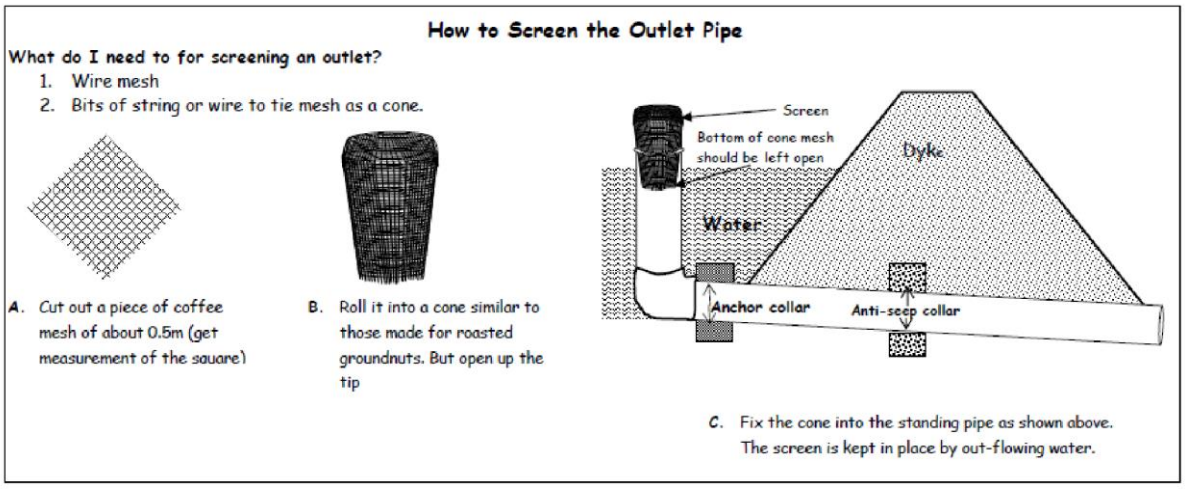

Figure 3-6: How to Screen the Outlet Pipe
(Source: Isyagi et al., 2009)

3.2.6 Bringing water to your pond

***Gravity flow*:** Ensure that the level of the drainage canal is at least 30 cm (11.8 inches) below the level of the pond bottom and at least 1.5 m (59 inches) below the level of the inlet canal. Canal slopes generally range from 0.25 to 1%, but for large ponds the slope should be about 0.5%.

Have in place a filtration system, to filter incoming water.

***Pumping*:** Avoid pumping water if there is a cheaper source. Pumping increases the cost of operation. Use the most economical water source.

***Other*:** Plan for a drop of 10 cm from the inlet pipe to the pond water level to prevent fish from swimming out of the pond through the pipe; better still, use a screen to prevent fish from entering the pipe.

3.2.7 Controlling water levels

i. If there is too much water in your pond, some may flow over the banks. This may wash the banks away and some of your fish may get out.
ii. You can use an overflow to keep the water in your pond from rising over the banks.
iii. It is best to place your overflow in the bank at the lower end of your pond right above the outlet so that the water that overflows can run off in the outlet ditch.

3.3 Pond preparation for existing ponds

Every pond must go through a stage of cleaning and dressing to make it suitable for fish growth.

The cleaning and dressing processes involve clearing and burning weeds, complete draining and bottom drying, disinfection, blocking and filling.

Here are some steps to consider when preparing an existing pond for stocking with fingerlings.

i. Ensure that the pond is completely drained. Close the inlet pipe and cover the opening with folds of fine mesh net to prevent the introduction of unwanted fish and any other biological agents.
ii. Eradicate all wild fish and any fish left over from the previous culture. The presence of any kind of fish will negatively affect the growth and survival of the new stock.
iii. Complete eradication may be done by drying the pond bottom within 1 to 2 weeks. If ponds cannot drain completely, apply environmentally friendly fish-killing agents (piscicides) such as rotenone, nim extracts or lime (application rate below), to eliminate the unwanted fish (Table 3-2).

Table 3-2: Natural and artificial agents for disinfecting ponds

Product	Doses
Quicklime little water in pond full pond	 500-900 g/m^3 200-250 g/m^3
Rotenone powder: usually 5% rotenone from *Derris* roots	20 g/m^3
Saponin, pure glycoside from plant	2-5 g/m^3
Derris root: from *Derris* spp., tuba; roots contain rotenone	20-40 g/m^3
Tephrosia leaves: leguminous tree; leaves contain rotenone	500 g/100 m^3
Barringtonia accutangula: powdered seeds	20 g/m^3
Croton tiglium: powdered oilseed cake	5 g/m^3
Milletia pachycarpa: powdered roots	5 g/m^3
Walsura piscidia: powdered bark	10 g/m^3
Bassia latifolia: oilcake; mahua (India)	250 g/m^3
Camellia spp.: teaseed cake; 10-13% saponin	50-70 g/m^3

(Source: FAO Training Series, 2010)

3.3.1 Liming a pond

Lime is used to disinfect ponds and neutralize acidic pond water. Always know the status of the pond before applying lime.

Follow these steps when liming a pond:

i. Put on appropriate farm attire (i.e., overalls, safety goggles, gloves and nose mask);
ii. Apply the appropriate rate of lime as presented in the table below. More lime may be required in acidic soil areas (Table 3-3);
iii. Broadcast (spread) lime according to the direction of the wind, ensuring that it covers all surfaces of the pond. Lime should be left in the pond for at least 24 hours before filling the pond. Leave water in the pond for at least two weeks before stocking (Plate 3-1);
iv. Do not apply the lime on a rainy day, since the concentration could be diluted, making it ineffective.

Plate 3-1: Liming the pond
(Agyakwah et al., 2018)

Table 3-3: Lime application rates for ponds

SOIL/WATER pH	pH GRADE	QUICK LIME (CaO) (g/m^2)	HYDRATED LIME [$Ca(OH)_2$] (g/m^2)	AGRIC LIME (g/m^2)
4-5	Highly acidic	150	150	200
5-6	Acidic	100	100	150
6-6.5	Low acidity	60	60	100
6.5-7	Neutral	20	20	40
7-9	Basic	-	-	-

3.3.2 Pond blocking and filling

After drying and liming the pond should be blocked and filled with water. Consider the following when filling your pond.

a. Ensure that water does not flow out of your pond.
b. There should be enough clean and unpolluted water from its source to fill your ponds.
c. Ensure that the inlet and outlet pipes are covered with nylon netting. This will prevent the entry of wild fish fry or eggs, river snails or small crustaceans like crabs, prawns or any other unwanted organisms.

CHAPTER 4 BRINGING FINGERLINGS TO YOUR POND

4.1 Where to obtain fingerlings

i. Obtain fingerlings from a certified hatchery or nursery. The hatchery or nursery should have a certificate issued by the Fisheries Commission.
ii. Ask other fish farmers about the quality and general condition of fingerlings from that hatchery or nursery.
iii. Observe the general condition of the fingerlings and hygienic condition of the hatchery or nursery.
iv. Purchased fingerlings should weigh between 5 and 10 grams.
Participate in the estimation of the fingerlings you want to buy.

4.2 Transporting fingerlings from hatchery or nursery to your pond

Transport of fingerlings involves the movement of fish: within the same farm (on-farm movement), from one farm to another, from one country to another, or from one culture system to another (e.g., from pond to cage). Certain principles and techniques must be used to ensure high survival rates, a clean environment and healthy fish.

Fish are generally transported in containers such as cans of different sizes, buckets, barrels, plastic bags, Styrofoam boxes, etc. In fact, almost any clean, waterproof container may be used as long as it provides suitable conditions for your fish. Certain containers offer good insulation from heat (e.g., wood or Styrofoam) while others, like metal or plastic, are poor insulators and may have to be wrapped with wet towels or packed with ice to keep temperatures down.

Once fish have been placed in their transport container they should be brought to their destination as quickly and smoothly as possible.

Whenever you're transporting fish, remember the principles below.

i. Care must be taken when transporting fish to your pond
ii. Fish must be well conditioned before transport (*See text box below*)
iii. Transport fish in the early morning or late evening (before sunrise or after sunset)
iv. Fish must be healthy and transported in clean waters
v. Fish can be transported in polybags or containers
vi. Use ice to reduce water temperature during transportation
vii. Load your fish in a ratio of 1 kg of fish to 1 kg (or 1 liter) of water
viii. Allow enough oxygen for aeration by inflating the polybag with oxygen
ix. If you carry your fish in poly bags, carry the bags in a box so that they do not break

How to condition fish prior to transportation

(Conditioning is normally done by the hatchery or nursery.) The steps are given below:

- *Prepare holding system (hapa, tanks, cage) before harvesting your fish;*
- *Harvest your fingerlings into the holding system;*
- *Estimate your fingerlings in your holding system. This can be done during harvesting or after harvesting when the fingerlings are in stable condition;*
- *Stock between 100 - 200 fingerlings (weighing 5 grams each, on average) per square meter of the holding system;*
- *Minimize feeding of fingerlings in the holding system;*
- *Observe the condition of fish and maintain good water quality;*
- *Condition your fish at least 7 days before transport;*
- *Do not feed your fish at least 1 day before transport.*

4.3 Stocking your pond with fish

i. Stock 4–8 fingerlings per square meter, depending on management and market needs or demand
ii. Stock fish early in the morning, if possible
iii. Before releasing fish into your pond, make sure the temperature of the receiving waters is about the same as the temperature of the transport water (do this by allowing a gradual exchange of water between the two).
iv. Fish should be allowed to swim out freely from the bags/containers into their new environment (Plate 4.21)
v. Be sure to take out any dead fish

Plate 4.21: Stocking fingerlings in ponds

CHAPTER 5 FEEDS AND FEEDING

5.1 Providing natural food

i. You can fertilize your pond (with organic or inorganic fertilizer) before stocking to stimulate the growth of small plants and animals that are good for your fish (Plate 5-1)
ii. Examples of organic fertilizers are chicken, cattle and pig droppings (application rate is between 50-100 grams per square meter)
iii. Droppings should be cured (Figure 5-1), if possible
iv. Examples of inorganic fertilizers are NPK (15:15:15) and superphosphate (application rate is 5 grams per square meter)
v. Fertilization is good for extensive and semi-intensive systems but may not be necessary for intensive systems
vi. If your water is green, you can be sure it is fertilized

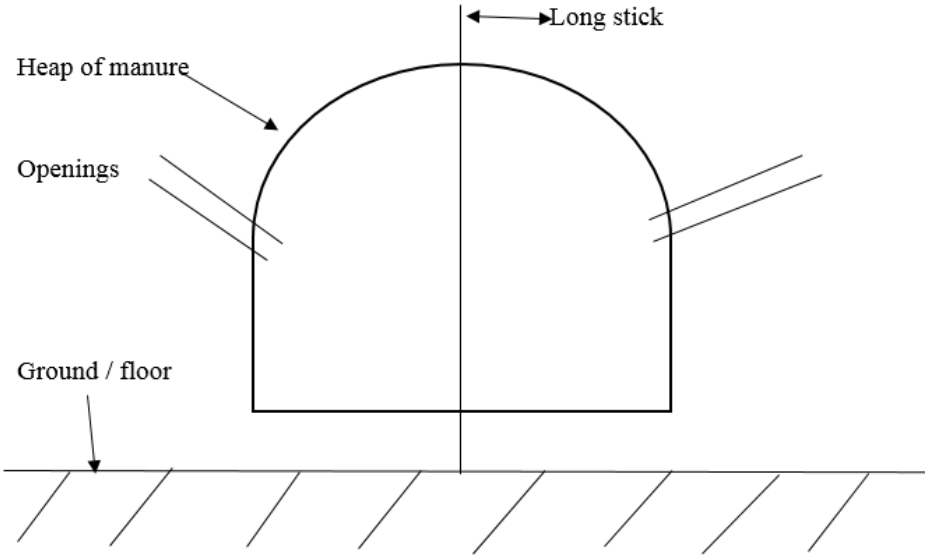

Figure 5-1: Diagram illustrates the manure curing process

When the manure is heaped on the ground, a long stick is placed at the peak. After several days (depending on the quantity of manure), the stick is removed. A cold stick indicates the manure is cured whereas a warm stick indicates the manure is not cured.

5.2 Feeding with formulated tilapia feed

i. To enhance fish growth, feed the fish with formulated feed from a certified source
ii. Ensure the feed is appropriate for the size/age of the fish
iii. Your fish will eat more as they grow but be careful not to overfeed
iv. Feed your fish at selected or identified feeding locations so that you can observe activity levels (Plate 5-2)
v. Feed your fish to satisfaction (by continually giving them small portions until they stop feeding) or based on their body weight (quantity of feed per day = biomass x % body weight, where biomass = average weight x total no. of fish)
vi. Feed your fish at least twice a day – they will grow better if you feed them regularly
vii. The bigger your fish grow, the more food they will need

viii. Uneaten food could indicate a problem (e.g., poor quality feed or deteriorated feed, low water temperature, sick fish)
ix. Formulated feed comes in powdered form for feeding fry and fingerlings and pellets for feeding juveniles and adult fish (Plate 5-3)
x. For fingerlings and juvenile fish, use feeds with protein levels of 38% and above
xi. As fish age, feed them with grower feeds of crude protein below 38% (
xii. Table 5-1)
xiii. A feeding protocol is provided to assist you in feeding (Table 5-1)

Recommended feed sizes for different development stages:

- Fry and larvae (0.01 - < 1 g): powdered feed;
- Fingerlings (1–5 g): Particle size, 0.5-2 mm (granules or crumbles);
- Juveniles (5–50 g): Particle size 2-3 mm;
- Adults (> 50 g): Particle size 3-6 mm.

Table 5-1: Protein requirement for different sizes of tilapia

Fish Size	**% CP Required**
< 20 g	40 - 45%
20 - 100 g	38 - 40%
100 - 250 g	33 - 35%
250 - 450 g	32 - 30%
> 450 g	28 - 30%

Plate 5-1: Process of pond fertilization

Plate 5-2: Feeding your fish or applying feed to a pond
(Source: Agyakwah et al., 2018)

Table 5-2: Organic manure application rates in ponds

INPUT	**MODE AND RATE OF APPLICATION**	
	BASAL BROADCAST / SAC-FILLED (g/m^2)	**TOP DRESSING (g/m^2/week)**
Chicken Manure	50	5
Pig manure	50	5
Cattle manure	100	10

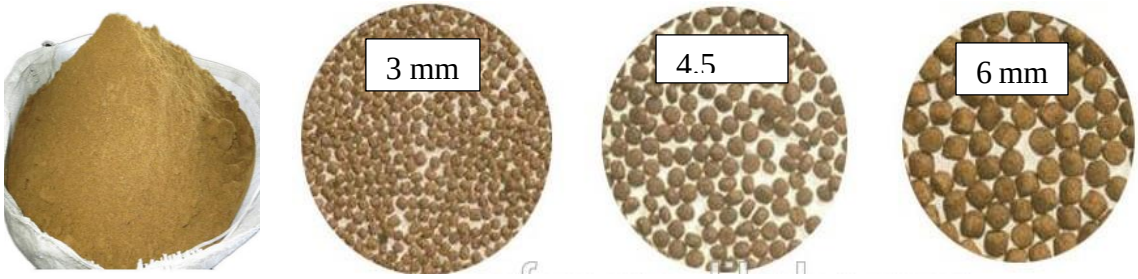

Plate 5-3: Powdered and pellet feeds
(Source: Agyakwah et al., 2018)

Table 5-3: Feeding protocol for tilapia based on optimal water quality and water temperature of 28 °C

INITIAL WEIGHT (GRAM)	**FINAL WEIGHT** (GRAM)	**FEED LEVEL** (%BW/DAY)	**FEED SIZE** (MM)
15	30	4.5	2
30	40	4.0	2
40	50	3.7	2
50	70	3.3	2
70	100	2.9	3
100	150	2.5	3
150	200	2.2	3
200	300	2.0	3
300	400	1.9	3/4.5
400	500	1.7	4.5
500	600	1.5	4.5
600	700	1.4	4.5
700	800	1.3	4.5
800	900	1.2	4.5

5.3 Feed purchase, storage and handling

i. Always check labels and buy the freshest diet in the store
ii. Purchase only the quantity of diet that will be consumed within 4 to 6 weeks
iii. During transportation and handling, protect the feed from moisture, heat and direct sunlight
iv. Feeds should be kept as dry and cool as possible
v. Pests such as mice, rats, cockroaches and ants must be prevented from getting to the feeds
vi. Do not store and use pesticides or other toxic materials near the feeds
vii. Rough handling of feeds should be avoided
viii. Do not stack bags of feed directly against a wall or on a concrete floor
ix. Bags of feed should be on pallets, away from the floor and wall to allow air to circulate around them, and to prevent moisture from coming in contact with the bags
x. Inventory should be used on a first-in/first-out basis
xi. Do not keep or use moldy or spoiled feed

CHAPTER 6 POND MANAGEMENT

A pond must be kept in a particular condition in order to ensure continual production.

6.1 Important things to note in pond management:

i. Ensure your water is from a good source;
ii. Aeration may be required at certain times of the day;
iii. Always maintain a minimum level (1 meter) of water in the pond (Plate 6-1);
iv. Make sure the pond screens are securely in place to prevent entry or escape of fish, larvae, eggs, toxins and pathogens;
v. Remove weeds growing excessively in ponds;
vi. All leakages in and around the pond must be sealed;

vii. Grasses should be planted along the pond walls and embankments – keep them short to prevent snakes, frogs and rats from hiding in them
viii. Do not allow animals such as cattle, goats, sheep, donkeys and horses to graze around your site as they may break your pond walls (Plate 6-1)
ix. Do not plant big trees near your pond.

Plate 6-1: Maintaining pond water level (a); Keep animals away from ponds (b)

6.2 Water quality management

Fish carry out all bodily functions in water. These functions include breathing, feeding, growth, reproduction and excretion. Water quality affects fish health, growth and performance. It is therefore a critical component of any fish-farming venture.

6.2.1 Signs and effects of poor water quality

i. Fish gasp at surface
ii. Fish groups around fresh incoming water
iii. Slow growth of fish
iv. Changes in water color (e.g., too greenish/brownish) or smell (Plate 6-2)
v. Increase in turbidity (water looks muddy, murky)
vi. Build-up of nitrogen compounds such as ammonia-nitrogen
vii. Phytoplankton blooms

6.2.2 Causes of bad water quality

i. Use of poor quality feed
ii. Overfeeding
iii. Overstocking
iv. Decomposition of vegetation
v. Polluted water source

Plate 6-2: Signs of bad water quality

6.2.3 How to manage water quality

i. Regular monitoring of key parameters
ii. Aerate when necessary
iii. Remove all dead fish as soon as you observe them
iv. Regularly change/renew pond water (minimum 2 to 3 times a week)
v. Apply appropriate stocking density
vi. Ensure appropriate feeding regime
vii. Regularly remove vegetation from ponds
viii. Reduce feeding and do not fertilize when pond water is bad

6.2.4 Disadvantages of poor water quality management

i. Poor growth
ii. High mortality
iii. Poor harvest
iv. High financial losses

6.2.5 Advantages of good water quality management

i. Good harvest
ii. Low mortalities
iii. Low vulnerability to fish diseases
iv. Tasty fish – no off-flavor
v. Increased profitability

6.2.6 Important water quality parameters and their acceptable ranges

i. pH (6.5–8.5)
ii. Dissolved Oxygen (> 3 mg/l)
iii. Temperature (25 – 30 ºC)
iv. Ammonia (< 0.03 mg/l)
v. Nitrite (< 0.6 mg/l)
vi. Turbidity (< 75 NTU)

6.3 Fish sampling

Sampling allows you to check on the health, growth and general well-being of your fish.

i. It is always advisable to sample frequently (i.e., monthly)
ii. Sample early in the morning before feeding
iii. Scoop a sample of the population (minimum 30 pieces), place it on a scale and divide the displayed weight by the total number of fish to get the average weight of the fish (Plate 6-3)
iv. The change in weight from the previous sample will tell you how your fish are growing
v. Remember, fish must always be in water to minimize stress during handling
vi. Wear gloves to handle fish
vii. Isolate fish that show signs of sickness and report immediately to Extension Officer
viii. Do not sample during extreme stress or poor/bad water quality

Plate 6-3: Processes involved in fish sampling
(Source: Agyakwah et al., 2018)

CHAPTER 7 BIOSECURITY MEASURES AND FISH HEALTH MANAGEMENT

7.1 Choice of farm location

The location of your fish farm is vital to its success. The location may influence other factors like the type of pond you choose to build and its water source. Choose a location suitable for the type of fish farming operation you intend to set up.

7.2 Design of farms

i. Know the planned land-use activities of the area
ii. Measures to be adopted on farm
    a. Ensure that all inputs and supplies (e.g., animals, feed, drugs and chemicals, etc.) coming into farm are from a certified source
    b. Incoming water should be safe, adequate and good quality
    c. Vehicles, equipment and visitors must have designated points with clear signage
    d. Regularly disinfect all equipment used to handle fish (
    e.
    f.

    g. Table 7-1)
    h. Maintain and improve standard of farm sanitation and hygiene (farm, equipment and staff/visitors) (
    i. Table 7-2)
    j. Dead animals and trash fish should be properly disposed of at designated sites
    k. Moribund animals should be kept in a safe location and properly disposed of at designated sites once dead
    l. Reduce stress levels in animals by avoiding overcrowding, overfeeding, underfeeding, over-fertilization of pond, excessive handling, etc.

7.3 How do diseases occur in the aquatic environment?

Environmental stressors (e.g., poor water quality, loads of sedimented waste that produce toxic gases), and the presence of opportunistic or infectious pathogens (e.g., viruses, bacteria, parasites and fungi) (Figure 7-1) and non-infectious (nutritional, genetic) defects can all lead to sick fish.

A change or shift in any of these factors can result in disease occurrence. Take note, this change does not just apply to infectious diseases but also to non-infectious diseases.

Table 7-1: Disinfection of equipment

Household bleach	• for non-metallic equipment only • make a stock solution at 250 ml/l • use diluted solution = 5 percent stock solution (3 to 4 tablespoons/l)
Iodophores	dosage = 250 ppm AI • Romeiod (0.5 percent AI): 50 ml/l (10 teaspoons/l) • Wescodyne (1.6 percent AI): 50 ml/3 l (10 teaspoons/3 l) • FAM 30 (2.75 percent AI): 50 ml/5 l (10 teaspoons/5 l)
Benzalkonium chlorides	dosage = 200 ppm AI • Roccal (25 percent AI): 4 ml/5 l (4 teaspoons/25 l) • Hyamine 3500 (50 percent AI): 2 ml/5 l (2 teaspoons/25 l)

Table 7-2: Disinfection of tanks

Chlorine bleach	for non-metallic tank dosage = 1 000 ppm Al for 20 min or 500 ppm Al for at least 1 h ● Chlorine bleach liquid 13 percent Al: 7.5 ml/l (7 500 ppm or about 1 200 ppm Al) for 20 min ● Chlorine bleach powder (33 percent Al): 3 ml/l (3 000 ppm or 1 000 ppm Al) for 20 min
Iodophores	dosage = 500 ppm Al for 10 min ● FAM 30 2.75 percent Al: 20 ml/l (4 teaspoons/l) ● Wescodyne 1.6 percent Al: 30 ml/l (2 tablespoons/l)
Potassium permanganate	dosage: = 1 g/100 l for 15 min

(Source: FAO Training Series, 2010)

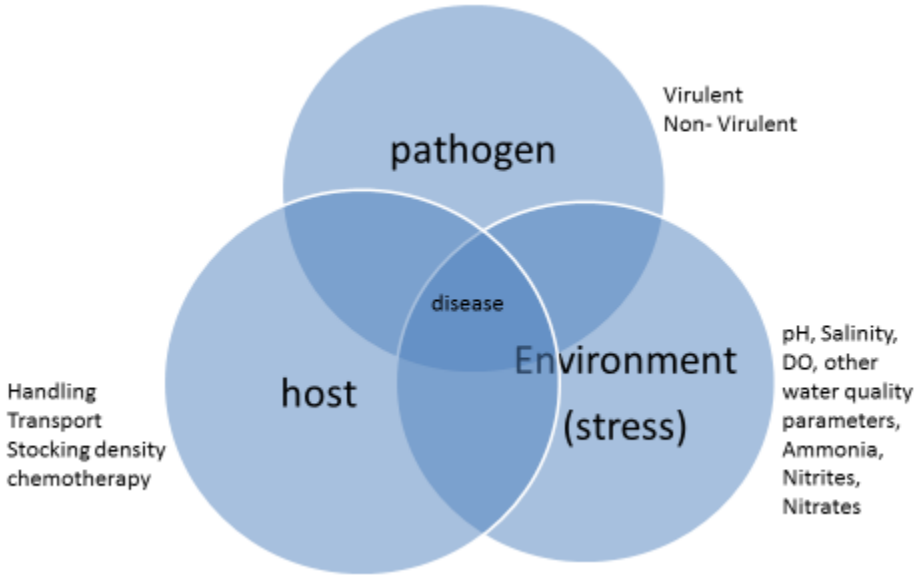

Figure 7-1: Host, pathogen and environment relationship

7.4 What are the causes of stress on fish?

i. Poor water quality (low dissolved oxygen, improper pH, high temperature)
ii. Pollution (chemical treatments, agro-based chemicals, spills)
iii. Diet composition
iv. Overcrowding
v. Predation and aggression
vi. Microorganisms (internal and external parasites, bacteria, viruses and fungi)
vii. Procedural stressors (handling, transport, treatments)

7.5 Common signs of diseases in fish

i. Erratic swimming
ii. Gulping for air
iii. Crowding at inlets and outlets
iv. Rubbing body against walls or protruding objects in the pond
v. Reduced or no feeding
vi. Pop/blind eye (Plate 7-1a)
vii. Wounds (Plate 7-1b)
viii. Swollen/ protruded abdomen (stomach) (Plate 7-1c)
ix. Mold or ulcerations on skin (Plate 7-1d)

These signs may not be definitive indicators of disease. Therefore, report any observed signs to an Extension Officer.

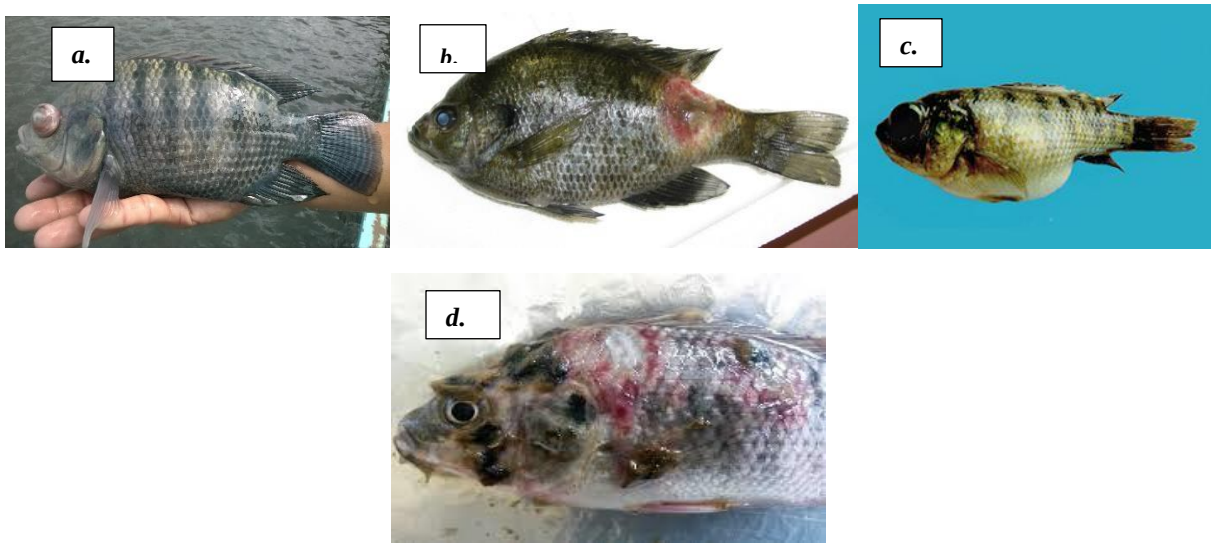

Plate 7-1: Some diseases of tilapia: a. pop eye, b. ulcerations on skin, c. swollen abdomen, d. molds and ulceration on skin

7.5 Sampling for laboratory diagnosis

i. Collect a dying or weak fish with a clean scoop net (disinfect scoop net before and after use)
ii. Put this fish into a clean (new) transparent plastic or cellophane bag
iii. Put the bag on ice in an ice-chest and transport to the laboratory
iv. Make sure this material is received appropriately at the laboratory with proper documentation

7.6 Controlling the spread of fish diseases

Upon signs of diseases, quarantine and restrict movement of fish. Report to an Extension Officer for advice on how to control fish diseases. Remove and bury dead fish as soon as you spot them (Plate 7-2).

It should be noted that any abnormality in fish conditions **should be** reported to the Extension Officer for further investigation.

Plate 7-2: Dead fish being buried

CHAPTER 8 HARVESTING AND MARKETING YOUR FISH

8.1 Considerations before harvesting fish for market

i. Do a market survey for fish prices
ii. Estimate your potential income from the harvest
iii. Decide whether to sell your fish to retail or wholesale buyers
iv. Ensure that market has been arranged first and is ready to take the fish (advertisement)
v. Decide on partial or total harvesting
vi. It is advisable not to feed fish for at least one day prior to harvesting for sale
vii. If possible, sample your fish prior to sale to check the flesh quality and/or taste

8.2 Harvesting your fish

Farmed fish can be harvested in several ways, either from a filled or drained pond, according to your needs. The following should be considered:

i. Harvesting should be done based on your marketing plan;
ii. When fish have reached a desired size or market demand is sufficient, it's time to harvest;
iii. Before harvest and sales, fish should be subjected to a health inspection;
iv. You can harvest your pond partially or totally;
v. It is advisable not to feed fish one or two days prior to harvesting for sale;
vi. Equipment used in harvesting might include a seine net, cast net, lift net and scoop net (Plate 8-1)
vii. Sort your fish based on size before going to market (Plate 8-2)

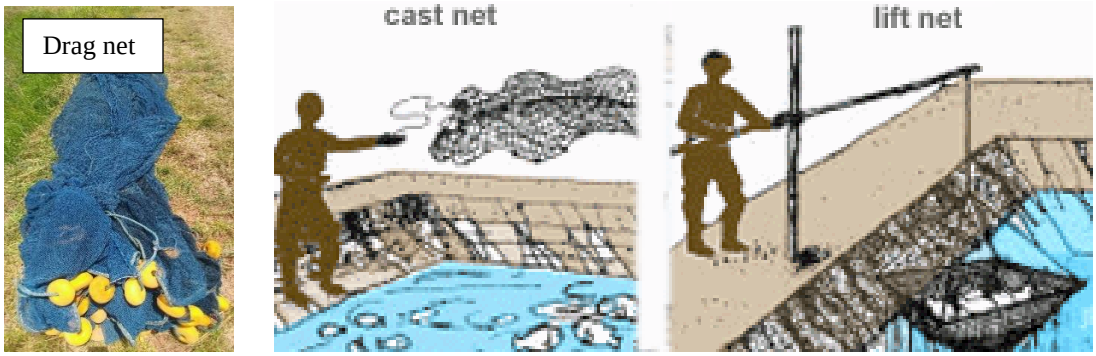

Plate 8-1: Some harvesting equipment

Plate 8-2: Processes in harvesting, sorting and sale of fish
(Source: Agyakwah et al., 2018)

8.2.1 Advantages and disadvantages of partial harvesting

i. You harvest you fish upon order
ii. You can get more value for your fish as you can target specific markets
iii. Greater frequency and additional harvesting times puts more stress on farm workers
i. It causes stress and weight loss in reserved fish
iv. You must feed reserved fish until your stock is sold – this could lead to additional costs
Reserved fish can be stolen

8.2.2 Effects of total harvesting

i. Less stressful for both fish and farmers
ii. Eliminates opportunities for thieves to steal your fish

8.2.3 How to maintain the freshness of your fish after harvesting

i. Stop feeding your fish at least 1 day before harvest
ii. Kill the fish rapidly before gutting or filleting them
iii. Use clean water and containers and avoid placing fish directly on the ground
iv. If fish are to be sold fresh, the best way to guarantee freshness is to sell the fish alive or on ice
v. For value addition, you can freeze, smoke, salt, dry or fillet your fish.

8.3 Marketing plan

Good marketing is essential for the commercial fish farmer to remain economically successful. To be able to sell more of your table-size fish at better prices, consider the following questions:

i. Where can you sell your table fish?
ii. Which kind of fish do the consumers prefer?
iii. To whom to sell your fish?
iv. How to sell your fish?
v. When to sell your fish?

vi. At which price to sell your fish?

Consider the channels below to identify advertising opportunities and build demand for your fish before harvesting.

i. Social media (mobile phones)
ii. Farmer associations
iii. Community radio announcements
iv. Fish dealers

CHAPTER 9 GOOD FARM MANAGEMENT PRACTICES

Good farm management practices include all activities that enable your fish to grow at an optimum rate.

i. It is advisable to have several ponds in order to harvest fish throughout the year.
ii. Stock your ponds at different times in order to harvest year round.
iii. Keep records of all activities (fertilizing, stocking, mortalities, feeding, harvesting, purchases, etc.) on your farm.
iv. You can further improve your fish farming by growing only male tilapia in your ponds (male tilapia grow faster than females because all of their food is used solely for growth).
v. Seek advice from an Extension /Fisheries Officer, routinely.

9.1 Recordkeeping

9.1.1 Farm Recordkeeping

i. It is always advisable to keep proper records of your farming operations in good format (
ii. Table 9-1).
iii. A lack of records or poor recordkeeping in any venture is likely to result in bad decision-making due to a lack of business insight.
iv. Records that are properly designed and stored and easily accessible are the best sources of information about your business – use them to drive your decisions.
v. Proper farm records are needed to improve the efficiency of the farm's operations and preserve the memory of the farm for future reference.
vi. Some important fish farming records include:
    a. Summary cost of production,
        - Cost of land
        - Pond construction
        - Inventory of farm assets
        - Source and cost of fingerlings
        - Cost of feeds
    b. Total number of ponds,
    c. Individual pond identity/dimensions,
    d. Stocking densities/numbers
    e. Dates of stocking and harvesting,
    f. Size/quantity of fish at stocking and harvesting,
    g. Mortalities,
    h. Quantities and cost of inputs used,
    i. Pond productions in quantities and values,
    j. Daily occurrences,

k. Salaries of farm workers,
l. Disease situations/outbreaks
m. Repairs and maintenance
n. Visitors/Extension Officer

Table 9-1: Recommended formats for recordkeeping

Field Inputs Log

A record of the materials you use for each field.

Farm Name or Unit: Field ID: Acres: Crop: Year:

Seeds / Transplants

Date	Crop / Variety Planted / Transplanted	Seeding Rate / Transplant Spacing

Fertilizers / Pest Control

Date	Material Applied / Brand or Source	Rate / Amount	Notes

RECORD FORM #11: Harvest Management and Yield Recordkeeping Form (Year: 20___)

Farm Name/Owner's Name: _____

Instructions: Use this form to document harvest of corn grain, silage crops, baleage, hay and small grain.

Field #	Crop	Harvest	Date Harvested		Yield Harvested			Total/	Yield/
Tract #	Description	Method	Start	Finish	Units	Size	Number	Field	Acre

RECORD FORM #8: Animal Confinement Log Sheet* (Year: 20___)[1]

Farm Name/Owner's Name: ______________________________

Instructions: Report the maximum number of each type of animal confined at each farm location at any one time.

Reporting Period (mm/dd/yyyy-mm/dd/yyyy)	No. of Days in Period	Type of Animal	Open Confinement			Housed Under Roof		Initials of Recorder
			Field ID	No. of Head	Vegetation Present at End of Period (Y/N)	Barn ID	No. of Head	

RECORD FORM # 6: Manure or Litter Transfer Record Form* (Year: 20___)[1]

Farm Name/Owner's Name: ______________________________

Instructions: Use this form to keep track of all manure, litter, or other materials generated at your farm that you transfer to other persons (i.e. for use or disposal not under the control of your farm). Have the recipient sign the form indicating they have received the nutrient analysis and environmental statement**.

Date of Transfer	Name & Address of Recipient	Person Making Entry	Amount Transferred		Manure Analysis			Total Nutrient Transfer		Signature of Recipient
			Manure (tons)/ Litter (tons)/ Other (tons/gallons)		N	P_2O_5		N (lbs)	P_2O_5 (lbs)	
04-01-11	*Jane Doe Farm, Route 7, Bluefield, WV.*	*Jane Doe*	2,000	☒ Tons ☐ Gals. ☐ Ac-In	*16*	*19*	☒ Lbs./ton ☐ Lbs./1000 gal ☐ Lbs./ac-in	*32,000*	*38,000*	
				☐ Tons ☐ Gals. ☐ Ac-In			☐ Lbs./ton ☐ Lbs./1000 gal ☐ Lbs./ac-in			
				☐ Tons ☐ Gals. ☐ Ac-In			☐ Lbs./ton ☐ Lbs./1000 gal ☐ Lbs./ac-in			
				☐ Tons ☐ Gals. ☐ Ac-In			☐ Lbs./ton ☐ Lbs./1000 gal ☐ Lbs./ac-in			
				☐ Tons ☐ Gals. ☐ Ac-In			☐ Lbs./ton ☐ Lbs./1000 gal ☐ Lbs./ac-in			

(Source: FAO Training Series, 2010)

9.2 Economic analysis

Actual price of pond materials, fingerlings stocked and feed used should be factored into the analysis. You should use the local market price when calculating the value of table-size fish.

Net Profit (P) = (Production x Price) – Cost (K)

or

Net profit (P) = Total Sale (S) – Total Cost (K)

$$\text{Return on total investment (\%)} = \frac{\text{Net profit (P)}}{\text{Total cost (K)}} \times 100$$

CHAPTER 10 BUSINESS MANAGEMENT AND PLANNING

Successful pond farming of tilapia as a commercial activity (business) requires knowledge and understanding of the aquaculture industry system, marketing system and its relationship to small-scale aquaculture enterprise (Figure 10-1). The most profitable pond farmers rigorously apply the fundamental principles of enterprise management in the context of inland freshwater aquaculture.

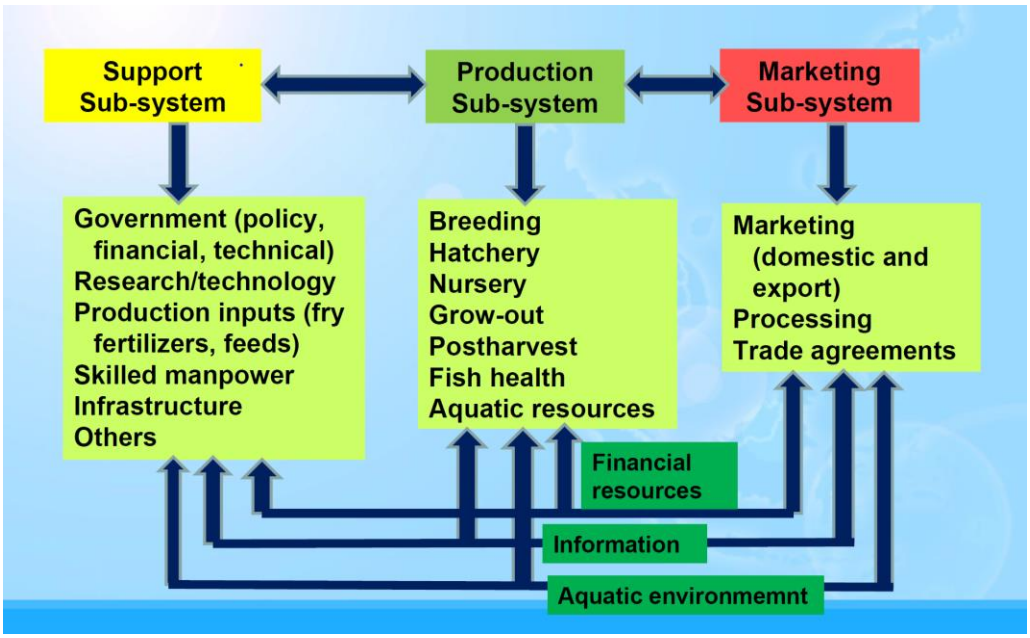

Figure 10-1: Aquaculture industry system showing relationships among the aquatic environment, production, marketing and support systems
(Source: JICA-SEAFDEC 2019 Aquaculture Training Handout)

10.1 Factors affecting profitability of aquaculture enterprise

i. Increase in production
ii. Increase in farm prices
iii. Reduction in cost

10.2 Enterprise management principles/rules

i. Know your business
ii. Understand your customers' requirements and preferences
iii. Prepare a realistic plan
iv. Build a good team with a good definition of roles
v. Monitor operation status and compare with the starting point (baseline)
vi. Write down important matters, and save it
vii. Ensure customer satisfaction

10.3 Marketing strategies

When operating a tilapia farm, you should develop and stick to market strategies that provide maximum benefits or returns to the business. Four (4) key factors (Figure 10-2), also referred to as "the marketing mix," that can be controlled to satisfy customers in target markets are:

i. Product - the good (e.g., table-size fish) or service that you provide
ii. Price - how much the consumer pays
iii. Place - the location where a product is marketed (e.g., on the farm, TV show, radio, web pages)
iv. Promotion - advertising the product to show consumers why they need it and should pay a certain price for it

The four Ps (i.e., Product, Price, Place and Promotion) are constrained by internal and external factors in the overall business environment, and they interact significantly with one another.

Figure 10-2: The marketing mix with the four Ps (Product, Price, Place and Promotion) and the interactive roles of process and people

i. Identify your key markets
ii. You can manipulate any of the four (4) Ps (i.e., Product, Price, Place and Promotion) in an optimal manner to satisfy customers in a target market

10.4 Market study

A resilient Nile tilapia grow-out farm (business) operator will desire to conduct market studies from time to time on customers' preferences for product (grow-out fish), price and even how to supply the produce/products. A market study should help you better understand the following:

i. Size, nature and growth of total demand for table-size fish
ii. Description and price of the fish product at different market levels
iii. Overall trend in supply, demand and prices in the fish market
iv. Market channels, pricing strategies and promotional tactics

v. Institutional, socio-economic and cultural characteristics of consumers

10.4.1 Dealing with risks and uncertainties in aquaculture

In aquaculture business planning, it is important to identify sources of risks and approaches to dealing with them, in order to prevent eventual collapse of the business. Some important sources of risks are:

i. Management and practices
ii. Environmental factors
iii. Weather and climatic factors
iv. Social considerations
v. Markets and prices of inputs and outputs
vi. Credit availability and interest rates
vii. Government regulations and policies (tax rates, subsidies)

10.4.2 Strategies to reduce risks and uncertainties

i. Diversification into other aquaculture systems (e.g., nursery polyculture, species switch) and agriculture operations (e.g., integration with vegetable, poultry or rice)
ii. Aquaculture insurance (though not available in Ghana presently)
iii. Improvement in production technology and practices
iv. Financial planning (improving cash flow)
v. Contract pricing (reducing cost)
vi. Equipment back-up (pumps, aerators)
vii. Management (improved practices)
viii. Education/training (improved skills)
ix. Adherence to regulatory requirements

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GLOSSARY

Aeration: The mechanical mixing of air and water
Ammonia: a colorless gas with a characteristic pungent smell, which dissolves in water to give a strongly alkaline solution
Bank: heap (a substance) into a mass or mound
Canal: an artificial waterway constructed to convey water
Certified hatchery: An accredited facility used for the artificial and controlled breeding, hatching and rearing of aquatic organisms, on a commercial or experimental basis
Culture: to grow or rear
Decomposition: the state or process of rotting; decay.
Disinfect: clean (something), especially with a chemical, in order to destroy bacteria
Dissolved oxygen: is a measure of how much oxygen is dissolved in the water
Ditch: a narrow channel dug at the side of a road or field, to hold or carry away water.
Dikes: a low wall serving as a boundary or fence.
Erratic swimming: swimming in a way that is not regular, certain, or expected
Excretion: the process of eliminating or expelling waste matter.
Filleting: to remove the bones from the fish
Filtration system: the process in which solid particles in a liquid or gaseous fluid are removed by the use of a filter medium that permits the fluid to pass through but retains the solid particles
Fingerlings: Related to any fish from advanced fry to about the size of a human finger
Freeboard: The additional height of a structure (e.g. dike, dam, canal wall) above designated high water level to prevent overflow
Fry: A term used to describe a fish at the post-larval stage
Gasp: to catch one's breath with an open mouth, owing to stress or pain
Gutting: remove the intestines and other internal organs from (a fish or other animal)
Hapa: it refers to a small, fine-mesh net enclosure set up in a shallow pond to raise fish larvae
Infectious pathogen: is a biological agent that causes disease or illness to its host
Juveniles: young fish
Larvae: an immature form of other animals that undergo some metamorphosis
Loss of appetite: means you do not have the same desire to eat as you used to
Microorganisms: An organism that can be seen only through a microscope and capable of causing infection
Mold: is a fungus that grows in the form of multicellular filaments called hyphae
Moribund: being in the state of dying
Mortality: the state of being subject to death.
Nursery: a pond designated for nursing young fish
pH: a figure expressing the acidity or alkalinity of a solution
Polluted: contaminated with harmful or poisonous substances
Predators: an animal that naturally preys on others.
Production cycle: is comprised of all activities related to the conversion of raw materials into finished goods
Slope: a surface of which one end or side is at a higher level than another; a rising or falling surface.
Temperature: the degree or intensity of heat present in a substance or object
Trenches: a long, narrow ditch.
Turbidity: the quality of being cloudy, opaque, or thick with suspended matter.
Water quality: refers to the chemical, physical and biological characteristics of water