

A NEW GUIDE TO **FISH FARMING IN KENYA**

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Aquaculture Collaborative Research Support Program

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INTRODUCTION

Kenya is endowed with numerous aquatic resources with aquacultural potential. It has highly varied climatic and geographic regions, covering a part of the Indian Ocean coastline, a portion of the largest freshwater lake in Africa (Lake Victoria), and several large rivers, swamps, and other wetlands, all of which support an abundance of native aquatic species. These aquatic environments range from marine and brackish waters to cold and warm fresh waters, and many can sustainably contribute to the operation of ponds for fish production.

Warmwater fish farming in ponds began in Kenya in the 1920s, initially using tilapia species and later including the common carp and the African catfish. In the 1960s rural fish farming was popularized by the Kenya Government through the "Eat More Fish" campaign; as a result of this effort, tilapia farming expanded rapidly, with the construction of many small ponds, especially in Kenya's Central and Western Provinces. However, the number of productive ponds declined in the 1970s, mainly because of inadequate extension services, a lack of quality fingerlings, and insufficient training for extension workers. Until the mid 1990s, fish farming in Kenya followed a pattern similar to that observed in many African countries, characterized by small ponds, subsistence-level management, and very low levels of production.

Today, following the renovation of several government fish rearing facilities, the establishment of research programs to determine best practices for pond culture, and an intensive training program for fisheries extension workers, there is renewed interest in fish farming in Kenya. Farmers in suitable areas across the country are again turning to fish farming as a way of producing high quality food, either for their families or for the market, and as a way of earning extra income. Because of recent locally conducted research and on-farm trials, farmers are learning that the application of appropriate techniques and good management can result in high yields and a good income.

The key to the continued development of fish farming in Kenya is to put the results of research conducted at government and university facilities into practical terms and make them available to farmers, extension workers, and trainers. This manual therefore seeks to make an updated introduction to the basic concepts of fish farming in Kenya available to all who need it. It is designed to follow up on previously available guides, such as *An Elementary Guide to Fish Farming*, produced by the Fisheries Department in 1987, by synthesizing technological information that has become available during the last 30 years, including research that has been conducted by the Aquaculture Collaborative Research Support Program. Though the manual has been designed for use in Kenya, the authors hope that it will be useful in other parts of Africa as well.

CHAPTER 1: AQUACULTURE PLANNING

A farmer considering culturing fish needs to consider a number of factors that may affect the success and profitability of the enterprise. Surveys for suitable sites or evaluations of specific sites should first identify strengths and weaknesses of physical characteristics such as the suitability of the soil, the topography of the land, and the availability of good quality water. Evaluations should also consider market demands, proximity to markets, and the availability of needed inputs such as fertilizers and feeds. In addition, all existing and planned uses of the catchment area should be studied to determine how they might contribute to or interfere with the farming enterprise.

This chapter addresses the questions of selecting good pond sites (Section 1.1), integrating fish culture into the farm as a whole (Section 1.2), and marketing the fish that have been produced (Section 1.3).

1.1: SELECTING A GOOD POND SITE

Introduction

In land-based aquaculture, the most commonly used culture units are earthen ponds. When evaluating and selecting sites for earthen fishponds, the main physical factors to consider are the land area, the water supply, and the soil. The following points should be kept in mind for each.

Land area

- Establish that the land is relatively level. Steeply sloped land is not generally suitable for building ponds. A slope of about 1% is considered ideal.
- Determine that the area is large enough for your present plans and for any future expansion.
- The area should not be prone to flooding. Study weather records for the area, ask local residents about flooding in recent years, and look for actual evidence that flooding has occurred.
- The area should not be subject to pollution in runoff from adjacent land. Find out who owns adjacent and uphill land, how they use the land, and what chemicals (including fertilizers and pesticides) they use.
- 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. Supplying water by gravity greatly reduces energy inputs and operating costs.
- In most cases the larger the surface area (with gentle slope), the better. This is only true if the land and water are not expensive.
- Consider development plans for neighboring areas and assess any causes for concern.



Figure 1.1-1. Relatively level land, as pictured above, is most suitable for building earthen ponds. Steep hillsides or very rocky areas are not suitable.

Water supply

The most common sources of water used for aquaculture are surface waters (streams, springs, lakes) and groundwater (wells, aquifers). Of these, wells and springs are generally preferred for their consistently high water quality.

- The quantity and quality of water should be adequate to support production through seasonal fluctuations.
- Determine that the quality of the intended water source is good enough for fish to thrive in.
 - ♦ A good water source will be relatively free of silt, aquatic insects, other potential predators, and toxic substances, and it will have a high concentration of dissolved oxygen.
 - ♦ If fish are already living and reproducing in the water (for example a river or lake), this is usually an indication that the quality is good.
 - ♦ Find out if the quality remains constant throughout the year or if there are seasonal changes that result in poor quality at certain times.
- Make the final site selection based on both the quality and quantity of water available.
- The quantity of water required depends on the species to be cultured and on the anticipated management practices, for example whether ponds will be operated as static ponds (no water flowing through) or as flow-through systems.



Figure 1.1-2. A good water source is one that provides high quality water in sufficient quantity throughout the year. Supplying water to ponds by gravity is preferable.

- ♦ Coldwater species like trout require a lot of water because they prefer a continuous supply of clean water with high dissolved oxygen concentrations (above 9 mg/L).
- ♦ Warmwater species like tilapia can tolerate water with lower dissolved oxygen levels, so tilapia culture is often done in static water, that is, without water flowing through the ponds. However, the best situation is to have a lot of “free” water, meaning water available by gravity flow, even if it is not always being used.
- For earthen ponds, the water source should be able to provide at least 1 m³ of water (1000 litres) per minute for each hectare of ponds that will be built. This quantity will be sufficient for quickly filling the ponds as well as for maintaining water levels throughout the culture period.
- If the selected site has relatively poor soils (i.e., soils containing too much sand) the source should be able to provide two to three times more water (2-3 m³ per minute per hectare). This quantity of water will be sufficient for maintaining water levels to compensate for losses that are likely to occur through seepage.

Soil

- Land should be comprised of good quality soil, with little or no gravel or rocks either on the surface or mixed in. Areas with rocky, gravelly, or sandy soil are not suitable for pond construction.
- The soil should be deep, extending down at least 1 metre below the surface. There should not be layers of rock lying close to the surface.
- Soils in the area where ponds will be built should have clay layers somewhere below the surface to prevent downward seepage.
- Soil that will be used to build the dykes must contain at least 20% clay so the finished pond will hold water throughout the growing period.
- Some soil with a higher clay content—preferably between 30 and 40%—should be available nearby. It will be used to pack the core trenches in the dykes.

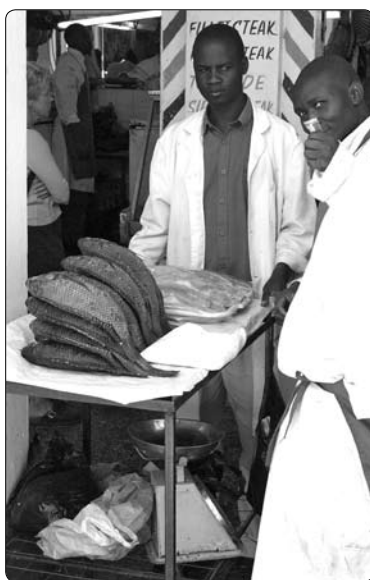
Other factors to consider

1. Proximity to a market

- Does market demand justify production?
- Will the existing physical infrastructure meet the farmer’s needs for marketing the fish?
- Will there be sufficient demand nearby or will transporting to a distant market often be a necessity? It is easier to sell at your doorstep or to have a permanent buyer who takes everything you can produce and either picks the fish up or is close enough that you can deliver the fish to them.



Figure 1.1-3. Your fish can be sold either on the pond bank or at a fish market.



2. Infrastructure

- Are the roads good enough to bring supplies to the farm and take the product to the market?
- Are telephone service and electrical power available at the site?
 - ♦ If an intensive production system is necessary due to constraints of space or water, access to power is a must. Electrical power is about two times cheaper than diesel power in Kenya (2006 prices).
 - ♦ Telephone service may be needed for ordering supplies, arranging marketing, or requesting technical assistance.

3. Availability of needed inputs

- Are fertilizers and lime available at reasonable cost?
- Are fingerlings available at a reasonable cost?
- Are fish feeds available for purchase, or are suitable ingredients available so the farmer can produce his own?

4. Personnel

- Hire qualified people as farm staff. Raising fish requires specific knowledge acquired only through training. However, training is not the only criterion to use when selecting workers: Look for workers who understand farming and are dedicated to a successful operation.

5. Access to Technical Advice

- Be sure good technical advice is readily available. Local extension agents or trained consultants are good possibilities. Remember: technical advice can be expensive and is sometimes wrong. Double-check advice received with a qualified individual (meaning they have produced a few tons of fish before) who is sincerely interested in your success. Good consultants admit when they don't know the needed information.
- Consider both criticism and compliments very carefully: The best advice may come in the form of criticism, and compliments can be misleading.
- Horticulture and animal husbandry consultants may know about business planning for agriculture but probably do not know enough about fish farming to give proper technical advice.

6. Competition

- Know who your competitors are and how much they sell their fish for. Consider whether you will be able to match their price and quality or even outsell them by producing a better product or selling at a lower price.
- If fish demand is high, cooperating with nearby fish producers to market the fish might be a possibility. The presence of several fish farmers in an area may make it possible for inputs to be obtained less expensively by forming a purchasing block (cooperative or group).

7. Legal issues

Consider whether or not there are any legal issues that will affect your ability to culture fish at this site. Would any of the following prevent you from going into fish farming: Land Use Act? Water Act? Environmental Management and Coordination Act? Others?

Moving on

If your site is suitable for pond construction with respect to land, soil, and water, and if you are satisfied that other selection criteria have been met, you can go ahead with planning.

1.2: INTEGRATING FISH CULTURE INTO YOUR FARM

Introduction

In addition to producing fish to eat or sell, there are other advantages to growing fish. Adding fish farming to other farm enterprises can make your overall operation more efficient and more profitable. This comes about by sharing space, inputs, byproducts, and labor associated with other crops, and especially by using or re-using materials available on the farm.

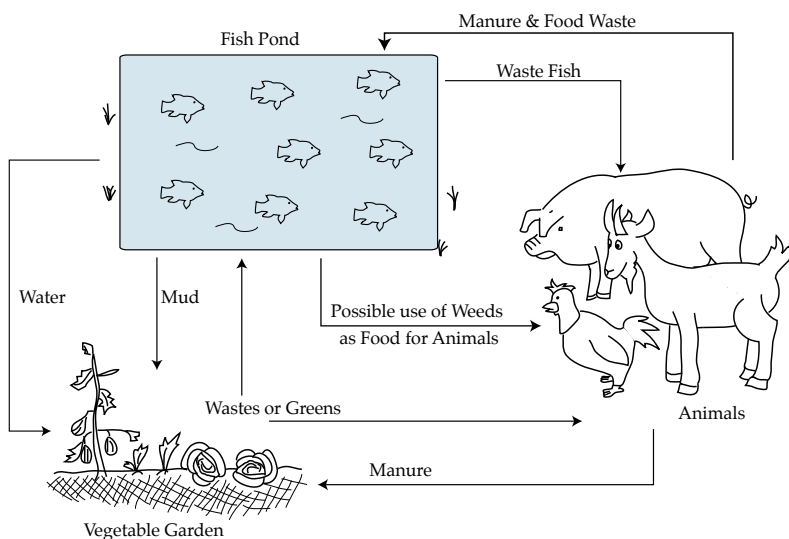


Figure 1.2-1. Many of the inputs, products, and byproducts of a farm can be shared to make the overall operation more economical.

Factors to consider

Some considerations of integrating fish culture into overall farm activities include:

- How much are you willing to invest in the project?
- How much time will be spent on fish production compared to other farm activities?
- Will growing fish enhance your food supply (when stocking fish for domestic use) or increase your income? Or are you engaging in the activity just because your neighbours have a similar project?

Methods

Once satisfied that a site is suitable for building a pond and that growing fish will be a profitable endeavour, here are some possible ways to integrate fish farming into your overall farm operation for greater efficiency and profitability:

- Plan your farm layout in such a way that work and materials will flow in a logical, smooth manner. For example, try to position crop, livestock, and fish units so that byproducts from one unit can easily be moved to another (One possible layout is shown in Figure 1.2-2). Also, if fishponds are positioned uphill from land crops it may be possible to use fertile pond water to irrigate your other crops by gravity.

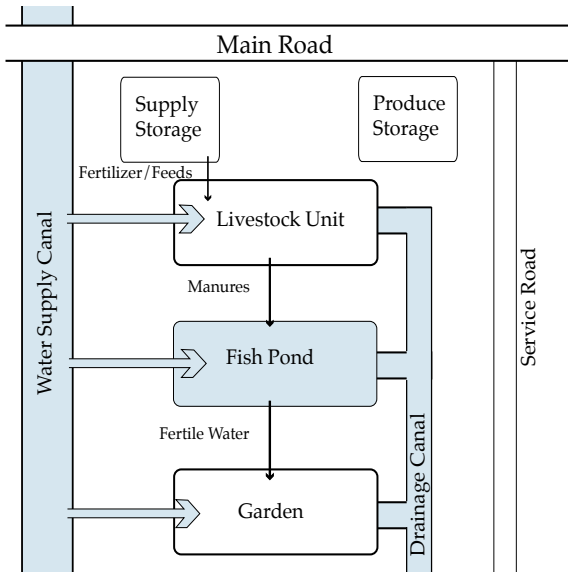


Figure 1.2-2. Illustration of a logical farm layout.

- Try byproducts from some farm activities as inputs for other activities. For example, animal manures may double as fertilizers for many crops, including fish.
- Use grasses cut as part of routine weeding or maintenance in your fertilization scheme. Some kinds of grasses can be used as feeds for animals, as well as for some species of fish. Most grasses can also be incorporated into composts, which make excellent fertilizers for many crops—including fish.
- Farms with chickens may consider building chicken houses over ponds, so chicken droppings and uneaten feed fall directly into the pond and serve as a fertilizer and food. About 1 chicken per 2 m² of pond surface area usually gives good results.
- Similarly, operations with pigs might build pigsties close to ponds so manure can be easily washed into the pond to fertilize it. In this case, be sure you can control the amount going into the pond so it is not overfertilized. Use about one pig per 166 m² of pond surface area.
- Other animals integrated with fish culture have included cattle, goats, sheep, ducks, geese, and rabbits.

- If rice is grown in paddies, it may be possible to rear fish in the rice paddies. This requires preparing the paddy a little differently than usual but can lead to an extra crop (fish) without reducing rice production. Consult your extension officer for advice on how to do this.
- Plan daily work activities so you accomplish as many tasks as possible on each trip. Try not to make any trip “empty handed.”
- Whenever possible, plan trips to the market or farm supply shop (e.g., for fertilizers or feeds) so purchasing and delivery of supplies for all enterprises is done in a single trip, rather than making several trips.
- Be creative in trying to find ways in which fish culture and your other farm enterprises can complement each other to help the farm reach top efficiency and a greater profit.



Figure 1.2-3. Chicken houses placed over ponds provide manure directly to ponds to reduce the cost of adding fertilizers.

Figure 1.2-4. Rice paddies can be slightly modified to rear fish. If properly done, rice production will not be reduced—and may even be increased—while a second crop (fish) is gained from the same land area and quantity of water.



Moving on

The integration of fish farming activities into your overall farm operation is an important consideration to look into prior to investing money and building ponds. Another critical consideration is how the fish will be marketed once they have been harvested. Some principles and tips regarding marketing are discussed in the next section.

1.3: MARKETING YOUR FISH

Introduction

Currently most fish produced in subsistence operations (usually less than 50 kg per harvest) are sold at the pond site. This way farm families satisfy their needs and sell excess to neighbours. For harvests larger than 50 kg, for example in semi-intensive settings, arrangements can be made with a buyer. Harvesting should be done regularly to satisfy the customer's needs, even if the amount they buy monthly or weekly is very little. This is called a "niche market," i.e., a market where the seller is assured of a small but regular outlet for their produce. You may also sell fish to restaurants or institutions such as schools or hospitals. It is advisable that small-scale producers form marketing groups, which will assure them a regular market.

Marketing studies

Before beginning a fish farming enterprise, a farmer should conduct a market study to help determine:

- The type and size of fish preferred by consumers (fingerlings, whole-fish, fillets, etc.)
- The quantity of fish required by the market.
- The best time to market fish.
- Which other farmers are supplying fish.
- The prices at which fish are being sold.

Farmers must bear in mind that the focus of all marketing activities is to satisfy the consumer.

- Every time a consumer buys fresh fish, whether in large or small quantities, what they are telling you is that you should continue to grow and sell fresh fish. In the case of fish traders, consumers are passing a signal back to the farmer telling them "produce more because I am ready to buy your product."
- If the consumer stops buying, the trader will also slow down on purchase of your fish. If this happens, they could be passing on information about the price of your product, the form of your product (fresh, frozen, or otherwise), or the quality of your product.
- A marketing system enticing consumers or traders to buy more fish from you is best.

What do consumers want?

- A marketing system that provides high-quality fish on demand at the lowest cost.
- Efficiency in the delivery of services.
- Reliability or assurance that the product will be there when needed.

Some basic marketing principles

- The efficient transfer of fish and fish products from the fish farmer to the consumer is vital in any fish marketing system.
- Fish is a perishable commodity and must be transported to the market quickly to avoid spoilage. If the market is not readily accessible, the product should be processed promptly before it loses quality.
 - ♦ Transportation and storage costs, which are directly related to physical handling of fish products, must be considered.
 - ♦ Storage of perishable commodities such as fish is more expensive than storage of nonperishables because of the cost of refrigeration.

Some tips for marketing your fish

- When fish are ready for sale, harvest and send them to the market immediately.
- You can increase the value of your product by doing some basic processing, either of the whole fish or of parts of the fish. Some possibilities include:
 - ♦ Deep fry the whole fish, starting with the smaller fish. This will prolong the shelf life of the product.
 - ♦ Cut the fish into several pieces, such as head, chest, tails, or fillets, then deep fry and sell them by the piece.
- When taking fish to the market, check prices and sell as quickly as possible. There are risks in holding fish for a long time waiting for the best price:
 - ♦ Time lag in the sale of products is a cost to the fish farmer. It will be less expensive to sell your fish at relatively lower prices than to store them for sale the next day.
 - ♦ Fish held for too long may spoil, becoming smelly or even unsafe, discouraging potential customers, and giving you a bad reputation. It will be difficult to overcome any negative



Figure 1.3-1. Markets in the larger towns can handle large quantities of many species of fish.

perceptions that consumers develop about farmed fish, and all farmers in a given market area may suffer.

- You should keep track of current consumer preferences and market prices for your product.
- It is often useful for farmers to organize themselves into cooperatives or use marketing agents; cooperatives have better bargaining power than solo operators.
- A useful rule of thumb is that fresh farmed fish whose source is known and whose quality is assured will fetch better prices and will out compete wild caught fish in Kenya.

Moving on

This chapter has focused on three important topics that should be considered before time and money are invested in a fish farming enterprise—choosing appropriate sites for pond development, integrating fish farming into larger farm operations, and marketing the product following harvest. The next chapter looks closely at how to design a good pond as well as at the actual process of building a pond.

CHAPTER 2: POND DESIGN AND CONSTRUCTION

Ponds and pond systems must be properly designed and built if a farmer is to be successful at fish farming. Ponds that are poorly designed or constructed can lead to a number of problems for the farmer, including ponds that don't hold water, ponds that cannot be drained completely (leading to incomplete harvests and poor production on subsequent production cycles), ponds that cannot be filled or drained by gravity, and dykes that fail. On the other hand, well-designed and constructed ponds are easily managed and maintained, leading to less "down time" due to failures and more efficient operation and production.

2.1: POND DESIGN AND LAYOUT

Introduction

Before beginning the construction of a new fishpond, carefully consider the design. A properly designed and constructed pond will be easily managed and will last longer, saving extra work and bringing greater profit. Some specific design considerations to address include:

1. The source of water used to fill the pond
2. How water will be brought to the pond
3. The type of soil available for building the pond
4. The size, shape, and depth of the pond
5. The slope of the pond bottom
6. The height, width, and slope of the dykes
7. The type of drainage system that will be used
8. The layout (arrangement) of ponds used for different sizes of fish

Other questions to consider

- What type of pond do you wish to build?
- What type of fish can be grown here?
 - ♦ Remember if you wish to be a fingerling producer, you will require more small ponds, whereas a food fish producer will require relatively large ponds.

General considerations

- Ponds should be designed based on the type of soil present and the intended culture practices.
- The water source must be able to keep the pond full throughout the culture period.
- Relatively shallow ponds are productive, but the shallow end should be at least 0.5 m deep to avoid invasion by weeds.
- It is always desirable to place screens on pond inlets and outlets to keep out predators, insects, and unwanted fish, and to retain the cultured fish.
- Every pond should be drainable.
- Every pond should have an independent controlled inlet and outlet.
- Excavation of a core trench should be done where soils are less suitable.
- Perimeter and feeder roads are required to provide for movement of machines during construction and at harvest.
- If you plan to drive on the dykes, build them at least 3 metres wide on top, and wider at the base.
- Soil used to build dykes should always be compacted in layers.

Specific design considerations

1. Water sources used for fishponds

Sources of water

- Water sources can be spring water, seepage water, rainwater or run-off, tidewater (marine ponds), water from bore holes (wells), or water pumped or diverted from a river, lake, or reservoir.

Quantity of water needed

- Make a decision on the type of fish to be cultured and the size of ponds, so as to determine the amount of water required.
- Consider the climatic condition of the area, rainfall pattern, and nature of the soil when calculating quantity of water.
- A general rule is that pond water inflow and outflow should equal the pond volume over the period of a month. If inflow is too low, water quality may suffer from oxygen depletion and/or the accumulation of toxicants. However, if the inflow is too high, large amounts of beneficial algae may be flushed from the pond.
- As a rule of thumb, ponds should fill up in less than a week. For small ponds, e.g., ponds smaller than 200 m², 1-inch pipe is recommended. A 400-m² pond needs a 2-inch pipe, while a pond larger than 4000 m² will require a 4-inch pipe (see Table 2.1-1).

Table 2.1-1. Delivery capacities of pipes of different sizes (1 m³ is equivalent to 1000 litres)

Pipe Diameter	m ³ /hr	m ³ /day (24 hrs)
1 inch	1.25	30
2 inches	6	144
4 inches	28	672
6 inches	80	1920
8 inches	136	3264

- To estimate the amount of water available from a specific source, use the simple bucket procedure:
 - a. Measure the capacity of a bucket and measure how long it takes to fill the bucket with water, e.g., a 10-litre bucket filling in 45 seconds. From this, calculate how many litres will be delivered per minute. This is estimated as $(10 \times 60)/45 = 13.3$ litres/minute.
 - b. Now determine how long it takes to fill a 100-m² pond (e.g., 10 m x 10 m). If the pond had a uniform depth of 1 m, it would hold 100 m³ of water. In actuality the pond does not hold 100 m³ of water, however. For example, if the pond is 50 cm deep at the shallow end and 90 cm deep at the deep end, its average depth is 70 cm or 0.7 m $(50 + 90)/2 = 70$ cm) and the volume of water required to fill the pond is 70 m³ or 70,000 litres $(100 \text{ m}^2 \times 0.7 \text{ m} = 70 \text{ m}^3)$.

- c. We also know that $1 \text{ m}^3 = 1000 \text{ litres}$. Since we know that our water supply gives us water at a rate of 13.3 litres per minute, we can now calculate how long it will take to fill the pond. This is calculated as $(70,000 \text{ litres} / 13.3 \text{ litres per minute} = 5263 \text{ minutes}$ or 87.7 hours. This pond will therefore require about three and a half days to fill.
- Remember that with sound management strategies one can successfully culture fish in ponds with inconsistent, undependable, or seasonal water sources.
 - Ponds lose water through seepage and evaporation.
 - ♦ The amount of water lost by evaporation depends on factors such as temperature, wind, vegetation, water surface, and humidity. Evaporation ranges from 2 to 7 mm per day. Assume 4 mm per day. So for 100 m^2 pond, water loss through evaporation would be $= 0.004 \text{ m} / 100 \text{ m}^2 = 0.4 \text{ m}^3$ or 400 litres in a day. So get enough water to replace what is lost by evaporation.
 - ♦ Water lost by seepage depends on soil and construction factors such as the existence of a suitable clay layer under the pond bottom, whether or not good clay cores were placed under the dykes during construction, and the quality of soil used to build the dykes.

Water quality requirements

- The best quality water will be free of silt and clay.
- Good water is also free of insect larvae, predators, unwanted fish species, pesticides and toxins, and excess fertility.
- Water supplied to ponds should be high in dissolved oxygen.

2. Bringing water to the pond

Gravity flow

- Ensure that the level of the drainage canal is below the level of the pond bottom and at least 1.5 m below the level of the inlet canal.
- The level of the inlet canal must allow a slope of 1:1000 to secure a reasonable flow of water; the slope of 1:1000 must work back to agree with the level of the intake.
- Canal slopes generally range from 0.25 to 1%, but for large ponds the slope should be about 0.5%.

Pumping

- Avoid pumping water if there is a cheaper source.
- Use the most economical water source.

Other

- Plan for a drop of 10 cm from inlet pipe to the pond water level to prevent fish from swimming out of pond into the pipe; better yet, use a screen to prevent fish from moving into the pipe.



Figure 2.1-1. Ponds at the Moi University Fish Farm are neatly laid out, with water flowing by gravity from the water reservoir (right) to the ponds (left).

3. Effects of soil types on pond design and construction

Range of soil types

- Topsoil is high in organic material and should not be used to construct pond dykes.
- The composition of mineral soils can range from very sandy to very clayey. These extremes are generally not suitable for fish pond construction. Sandy soils are too porous to hold water, while clay is too compact and adsorptive, depriving the water of essential nutrient elements, particularly phosphorus.
- Soils with 20-35% clay are the best for building ponds.
- Pond bottoms may be classified into three general types:
 - ♦ Inorganic bottoms of gravel, sand, or clay, which are very poor but can be improved by the application of manure or sludge.
 - ♦ Peaty bottoms formed by the accumulation of un-decomposed vegetable debris, which can be corrected by using heavy doses of lime to bring about decomposition.
 - ♦ Mud bottoms, which are the most productive type.

Effects on pond design and construction

- If the site has some soil containing a high percentage of clay (30-35% or more), use this for filling the core trenches beneath the dykes (see Section 2.2 for further information on constructing cores).
- If your soil has a reasonable percentage of clay (20-30%), you can construct the dykes 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 dyke slopes to 3:1 to prevent slumping and erosion of the pond banks.

4. Pond size, shape, and depth

Size

- The size of a prospective fish pond should be based on the purpose of the pond.
- If the pond is meant to provide additional food for the family, then it need not be larger than 0.1 ha (1000 m²).
- Larger ponds produce more fish and are usually more efficient producers of fish per unit of land than ponds less than 1000 m².
- A pond of 0.2-0.3 ha (2000-3000 m²) is easily managed by a small farm family. Such ponds can be maintained with a minimum of effort.

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

- The best pond depth depends on the fish species, size of fish, and production system to be used.
- The ideal depth for most ponds ranges from 0.75 to 1.2 m.
- For the shallow end, the depth can be from 40 to 70 cm. The absolute minimum is 40 cm; however, 50 to 60 cm is best. Problems that develop in shallow ponds include predation, weeds, and low production.



Figure 2.1-2. A well designed pond allows for a water depth of about 1 metre and has embankments (dykes) with inside slopes of 2 to 1 or greater, depending on soil type.

- The deep end can be from 80 to 120 cm deep, but the best for medium and large ponds is 90 to 110 cm. Areas deeper than 1 m are likely to be less productive: They are cooler than the surface, lower in oxygen, and can become stratified, so most fish will avoid them.
- A small pond of 150 m² (e.g., 15 m x 10 m) with dyke slopes of 2:1 should have a shallow end 50 cm deep and a deep end 75 cm deep.
- The deepest point should be at the outlet.
- The total height of the dykes of such a pond will be 80 cm on the shallow end and 105 cm towards the outlet.
- Remember that sunlight can penetrate up to 1 metre into clear waters, for example in unfertilized ponds. In fertilized fishponds light penetration beyond 60 cm below the water surface is minimal.

5. The slope of the pond bottom

- The pond bottom must have sufficient slope for good drainage. In general, slopes with a drop of 2 cm for every 10 metres along the pond bottom are appropriate.
- 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.

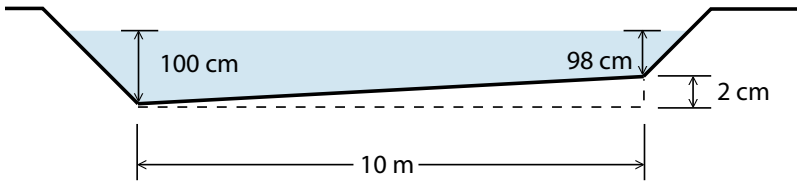


Figure 2.1-3. A well designed pond slopes slightly from the shallow end to the deep end, with a drop of about 2 cm for every 10 metres of length.

6. Design of the dykes—height, width, and slope

Height of dykes

- Dyke height will be set by the depths that you have chosen for the shallow and deep ends of the pond. However, dykes must be built higher than the full water level to guard against overflowing. The additional height of the dyke above the full water level is called “freeboard.”
- Freeboards for ponds less than 1000 m² should range between 20 and 30 cm, but for larger ponds they can be up to 50 cm.

Width

- The width of the dyke at its top should be equal its height but never less than a metre wide.
- The width should be great enough to allow transport of materials, fish, and farm equipment.

Slope

- Slopes that are too steep lead to problems such as erosion and slumping of the dykes.
- Gentle slopes are better due to water pressure, which is highest at the pond bottom; however, slopes that are too gentle encourage the growth of weeds in the pond.
- The slope of the dyke depends on soil type:
 - ♦ The inside slope should be 2:1 to allow water pressure dispersion. The slope should be increased to 2.5:1 if the soil is of lower quality.
 - ♦ The outside slope can be 1:1.
- The width of the base on firm soils should be three to four times the height of the wall. This should be five times the height of the wall on soft soils and with a crest of not less than 1.2 to 1.5 metres.

7. Pond drainage systems

- Pond drains are normally located at the deep end of the pond with the bottom sloping toward them. Most of the ponds used by small-scale farmers do not have drains. In the case of very small ponds, it is of course uneconomical to provide individual drainage facilities.
- Periodic draining and drying of ponds is important because it helps in harvesting fish, eradicating predators, improving the bottom condition of the ponds, and raising production rates.

Standpipes

- The simplest drain is a standpipe protruding from the pond bottom. The lower end of the standpipe is screwed into an elbow which connects to the main drain. The upper end controls the level of water in the pond.
- When the water level is to be raised or lowered, the angle of the standpipe is changed by rotating the elbow.
- The size of the standpipe depends on the size of the pond, the rate at which drainage is desired, and the volume of water coming into the pond for a flow through system.

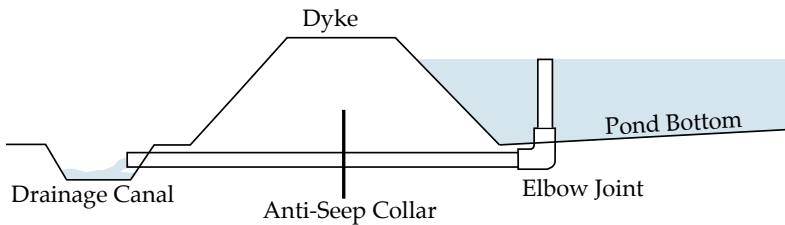


Figure 2.1-4. A cross section of a pond dyke and drainline with standpipe. The maximum water depth is obtained when the standpipe is in a vertical position; the water depth can be lowered by turning the standpipe down towards the pond bottom.

Monks

- The monk is part of the drainage system. It is constructed in front of the dyke (inside the pond) and consists of two parallel lateral walls and a back wall. It can be made of brick or concrete. Boards are placed in slots in the lateral walls to retain water at a desired depth.
- The monk controls the level of water in the pond, prevents escape of fish, and permits progressive draining of the pond during harvesting.
- Monks may prove uneconomical and unnecessary in small ponds. In such ponds it is more economical to dig canals through the dykes to fill, drain, or maintain a consistent water inflow and outflow.

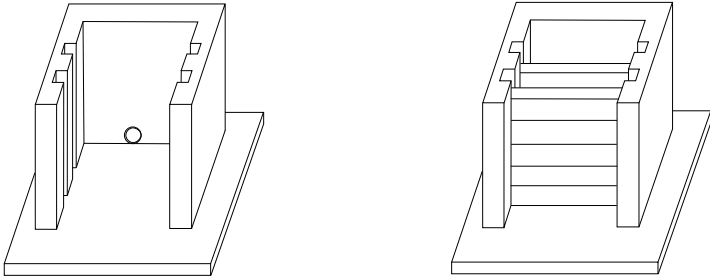


Figure 2.1-5. A figure of a monk. Boards are inserted on edge into the slots to hold water in the pond. A tight seal is obtained by packing clay into the space between the two sets of boards.

8. Layout of ponds

Integrating fish ponds into your general farm layout was discussed in Section 1.2. Within the fish production unit itself, you should lay out and construct your broodfish ponds, spawning ponds, nursery ponds, and growout ponds in sequence and close to each other so that you can move fish from one rearing phase to another easily and quickly. One way of doing this is shown in Figure 2.1-6.

Moving on

With these principles of good pond design in mind, you are ready to move on to the next step—the actual construction of your ponds.

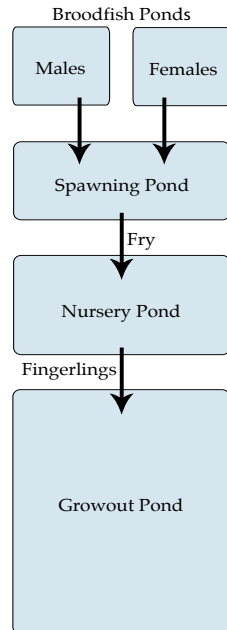


Figure 2.1-6. A logical pond layout provides for easy movement of fish from one rearing phase (pond) to another.

2.2: POND CONSTRUCTION

Introduction

Once you have designed your pond there is a logical sequence of steps that you should follow to build it. These are:

1. Survey the land
2. Clear all vegetation from the site
3. Remove the topsoil from the site
4. Determine pond, drain pipe, and supply canal elevations
5. Peg out the pond, including core trenches, dyke tops, and dyke toes
6. Dig core trenches and pack them with good soil
7. Excavate the pond area
8. Build the dykes
9. Install the drainage system
10. Install the water supply system

Building your pond

1. Surveying the land

- Clear the land to get line of sight.
- Select a reference point for the survey. The standard reference point (“bench mark”) is sea level (0 m above sea level). However, in pond construction we use a Temporary Bench Mark (TBM) to help determine elevations and establish slopes. If there is an existing pond use it as the reference point to get the heights of your dykes. If there are no existing ponds, use a fixed point on an inlet or outlet canal as the TBM.
- Start measuring elevations from the supply canal using a level and twine. Determine slope from dyke top to pond bottom for both vertical and horizontal dimensions. This helps in understanding how water will flow from the pond to the drain or back to the river. Raise elevation into canals by blocking with timber or sand bags.
- Survey across water bodies using objects such as bamboo, pipes, etc.

2. Clearing vegetation from the site

- Vegetation should not be included in the soil used to construct the pond dykes, so should be removed from the site prior to beginning to excavate and move soil.

3. Removing topsoil from the site

- Topsoil is not good material to use for dyke construction, so it should be removed prior to excavating the pond.
- Topsoil can be set aside and spread over the dykes after construction is complete, or it can be moved for use elsewhere on your farm, for example in your vegetable garden.

4. Determining pond, drain pipe, and supply canal elevations

- Determine topography (layout) of the land first.



Figure 2.2-1. Vegetation and topsoil should be removed from the area before beginning to build a pond.

- Remember that the elevations of the pond inlet and the outlet to the drain canal determine the elevation at which the pond drain can be placed. Hence the difference in the elevations of the inlet and the outlet determines how deep your pond can be.
- Remember to allow for the freeboard.
- Canal slopes generally range from 0.25% to 1%.
- Cross check your levels to correspond with the TBM so as not to lose dyke height.
- You can also check your pond diagonally, widthwise, and lengthwise.

5. Pegging out the dykes and core trenches

- Decide on the size of the pond and peg the pond area.
- Decide on the dyke slope and width.
- Place pegs at the inner toes, including the four bottom corners. The “toe” is the point where the dyke slope meets the pond bottom. To do this, multiply the desired slope of the dyke by the desired pond depth. For example, at the deep end, the inner toes will be pegged at $80 \text{ cm} \times 2 = 160 \text{ cm}$, while at the shallow end the inner toes will be pegged at $75 \text{ cm} \times 2 = 150 \text{ cm}$.

6. Constructing cores

- If you suspect the dyke or pond bottom soil to be highly permeable, dig a core trench under the dykes around the pond.
- Pack the core trenches with impermeable clay.

7. Excavating the pond area

- Make a decision on pond depth and calculate the dig/fill heights (See Table 2.2-1).
- Begin excavating the pond bottom.



Figure 2.2-2. Pond construction typically involves excavating the inner area and using that soil to build the embankments.



Figure 2.2-3. This area has been pegged out and core trench digging has begun. The core will be packed with soil containing not less than 30% clay before dyke construction begins.

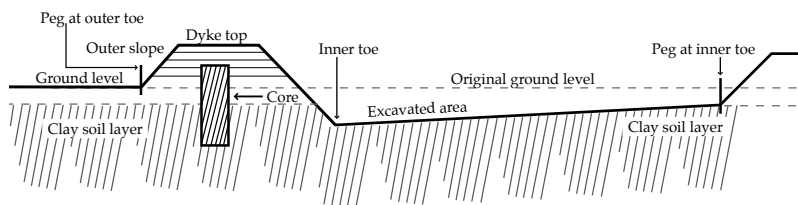


Figure 2.2-4. This cross section shows the relationships of the dyke, inner and outer toes, and the core to the original ground level and clay layer beneath the pond bottom.

- Plan where you take soil from and where you take it to. The fewer times soil is handled, the more efficient and less expensive the project is. Poor organization of soil movement increases labour cost and also results in a poorly shaped pond.
- A two-person stretcher works better in black cotton soil than a wheelbarrow. But one person using a wheelbarrow can move the same amount of soil as two people using a stretcher.
- Black cotton soil (the heavy, black clay soil common in some lowland areas) has a large potential to expand and contract, so large cracks frequently develop in the soil. Do not get this soil too wet during construction — only wet it enough for good compaction.

Table 2.2-1. This table shows the approximate excavation depths that will be needed at different distances from a reference point on land of different slopes.

Slope	1 m	5 m	10 m	100 m
1%	0.01 m	0.05 m	0.1 m	1 m
0.5%	0.005 m	0.025 m	0.05 m	0.5 m
0.25%	0.0025 m	0.0125 m	0.025 m	0.25 m



Figure 2.2-5. A two-person stretcher works very well for moving soil from the excavated area to the embankment area, especially in heavy clay soils.

8. Constructing the dykes (levees)

- The most important component of a pond is its walls (also referred to as the “dykes,” “levees,” or “embankments”).
- Use soil excavated from the pond area to construct the dykes.
- Construct the dykes gradually, in layers about 20 cm thick at a time.
- Compact each layer before the next layer is put down.

9. Installing the drainage system

- Install the drain after the dyke has been raised at least above the original ground level.
- Cut a trench for the drain pipe across the dyke at the selected point in the deep end.
- The top of the drain pipe should be below the deepest part of the pond.
- Lay the pipe at the proper slope through the dyke; slope should be not less than 1%.
- Install at least one “anti-seep collar” along the drain pipe (see Fig. 2.1-4).

- For small ponds, a PVC pipe fitted with a gate valve would be more suitable than a gate with timber boards.
- Place a screen at the outflow to keep out predators and unwanted fish, and to retain the cultured fish.



Figure 2.2-6. Dyke construction is done in layers about 20 cm thick. Each layer is well compacted before the next layer is added.



Figure 2.2-7. A PVC standpipe being installed in a new pond. With the standpipe in the vertical position the full pond will have a water depth of approximately 1 m.



Figure 2.2-8. Although more expensive to construct, monks are sometimes used instead of standpipes. In this example, some of the upper boards have been removed to lower the water level in the pond.

10. Installing the water supply system

- Inlets deliver water to the fish ponds while outlets regulate the water level in the ponds and ensure complete drainage.
- Canals or pipes can be used to bring water to the pond. Types of delivery systems include open canal, channel lines with bricks and/or stones (open channel in black cotton soil can have cracks), PVC pipes, bamboo pipes, tiles, and gate valves.
- The inlet should preferably be directly opposite the outlet. This allows proper mixing of water in the pond and of course heat dispersion.
- Place the inlet at the middle of the dyke on the shallow end, and make it smaller than outlet (overflow).
- Do not let the canal end at the pond because in times of floods there is need to allow water to bypass the pond without causing any flooding.
- Raise diversion canals into the pond slightly higher (e.g., 2 cm) than the feeder canal.
- Allow for water to drop at least 30 cm between the inlet pipe and water level (surface). This area is referred to as the free board (mentioned earlier).
- Give the inlet canal a slope of 0.5% and work out the depth as explained earlier. For example, for every 5 metres you will have a drop of 2.5 cm to maintain a slope of 0.5% calculated as shown:
$$2.5 \text{ cm} / 5 \text{ m} \times 100 = 25 \text{ cm} / 5000 \text{ cm} = 0.5\%$$
- You can also siphon water from a higher pond to a lower one.
- Water brought into the pond should be passed through a screen to keep out insects and other predators.

Estimating pond construction costs

Example 1

One pond of 100 m² requires about 15 people working 8 hours to construct in 8 days. This will cost $15 \times 8 \times \text{Kshs } 127 = 15,240.00$. Alternatively if 8 people are constructing a 100 m² pond they will be required to work for 15-16 days at an average of 8 hours per day. The cost will be $8 \times 16 \times \text{Kshs } 127 = 16,256.00$. Inlet canal, outlet canal, cement, sand, and pipes will cost about Kshs 5,000.00. Total cost of the pond should be Kshs 21,256.00. Consider other incidentals especially due to the prevailing weather. This may have an additional cost of about Kshs 3,750.00. In total, the cost of constructing one 100 m² pond should be Kshs 25,000.00 (US\$ 338.00 at an exchange rate of Kshs 74.00 to a dollar).

Example 2

If 8 people are constructing 300 m² pond they will be required to work for 26.25 days at an average rate of 8 hours per day. The cost will be $8 \times 26.25 \times \text{Kshs } 127 = 26,670.00$. Inlet canal, outlet canal, cement, sand, and pipes will cost an additional Kshs 5,000.00. Total cost of the pond should be Kshs 31,670.00. Now consider other incidentals especially due to the prevailing weather, which may bring in an additional cost of about Kshs 3,750.00. Therefore, the total cost of constructing a 300 m² pond should be Kshs 35,420.00 (US\$ 479.00).

Moving soil

A 100 m² pond whose average depth is 70 cm will have $10 \times 10 \times 0.7 \text{ m} = 70 \text{ m}^3$ of soil to be moved or excavated. This should take 8 people about 8 days if they each dig 1 m³ of soil, move it to the dyke area and compact it. Ideally, the amount of soil to be excavated from the pond area would be about equal to the soil needed to construct the dykes. This can occur if the land has a gentle slope, allowing for the amount of the soil removed from the pond to be just enough to raise the dykes to the required level. Generally, however, the volume of the soil on the dyke (the total dyke surface area for 100 m²) is about 120 m³; this is more than the volume to be excavated from the pond area, so some additional soil will need to be brought in.

Moving on

Now that you have designed and constructed your new pond, you are ready to prepare and stock it for your first crop of fish. The next chapter reviews the major species that are suitable for fish farming in Kenya.

CHAPTER 3: SPECIES SUITABLE FOR CULTURE IN KENYA

Culture systems found in Kenya include semi-intensive culture of Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*), practiced by small-scale fish farmers in static ponds, and intensive culture of trout in raceways. The species used at any given site are mainly endemic to the region and more or less appropriate to the agroclimatic zone. For example, tilapia is a warmwater fish and is mainly cultured in a freshwater environment. Catfish are grown in the same agroclimatic region as tilapia, but trout, an introduced coldwater fish, is best grown in high altitude regions where the water is cooler. The major drawback of culturing tilapias in ponds is the risk of uncontrolled reproduction. The challenge with catfish production is high mortality of fry, especially during the first 14 days after the eggs hatch. Trout production is presently limited by the availability of seed and quality feeds in the country.

Desirable characteristics for cultured fish species include:

- Ease of reproduction
- Attainment of market size prior to reaching sexual maturity
- Acceptance of supplemental and/or manufactured feeds
- Feeds low on the food chain, i.e., eats plant material
- Rapid growth
- Efficient feed conversion
- Resistance to diseases
- Tolerance to relatively high stocking density and poor environmental conditions
- Is highly desired in the marketplace

Few species have all of these characteristics, but both the Nile tilapia and the African catfish have enough of them that their popularity in the market and the ready availability of technical information about their culture make them suitable candidates for warmwater fish farming in Kenya.

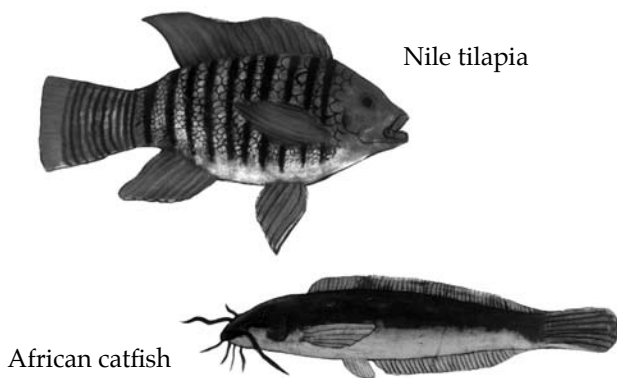


Figure 3.1 The Nile tilapia and the African catfish are the two most commonly cultured species in Kenya.

3.1: NILE TILAPIA

Introduction

Tilapia grow best in waters with a temperature range of 20-35°C. They can grow up to 500 g in eight months if breeding is controlled and food supply is adequate. Juvenile tilapia feed on phytoplankton, zooplankton, and detritus, but adults feed almost exclusively on phytoplankton. Tilapia can reach sexual maturity at two months of age or at 10 cm or less in length. Hence, the major drawback with tilapia culture is their tendency to over breed, which can result in a large population of stunted (undersized) fish. Some relevant characteristics of tilapia are described here, along with information about husbandry techniques.



Figure 3.1-1. Nile tilapia, *Oreochromis niloticus*.

Temperature tolerances

- Various strains of Nile tilapia differ with respect to their tolerance to cold, but growth is generally limited at temperatures below 16°C and most strains become severely stressed at 13°C.
- Death begins to occur at 12°C, with few fish surviving temperatures below 10°C for any period of time.
- Nile tilapia do not feed or grow at water temperatures below 15°C and do not spawn at temperatures below 20°C.
- The normal water temperature should be 20-30°C, preferably about 28°C, which is considered the ideal temperature for good health and growth. At higher temperatures their metabolic rate rises, leading, in extreme cases, to death.
- Gradual conditioning would allow tilapia to live within a range of 8-40°C.

Tolerance of low dissolved oxygen (DO) concentrations

- Tilapia are able to survive levels of dissolved oxygen (DO) below 2.3 mg/L as long as temperature and pH remain favourable.
- In fertilized ponds, a bloom of algae can reduce oxygen levels to as low as 0.3 mg/L with no fish mortality in tilapia.
- Larger fish are known to be less tolerant than fingerlings; this is due to metabolic demand.

Maturation

- It has been observed that under natural conditions tilapia mature at a larger size and later age than they do when cultured in ponds. This can take two to three years.
- The age and size at which maturity is reached also depends on conditions in the water body.
- Tilapia cultured in ponds sometimes mature at as early as two months, but generally mature in four to six months.

Feeding habits

- Nile tilapia are omnivorous, feeding lower on the food chain on phytoplankton, zooplankton, aquatic insects, and macrophytes.

Breeding behaviour

- Mature tilapia can spawn about once a month all year round if temperatures remain above 22°C; below 22°C spawning will be seasonal.
- In actively breeding populations of tilapia, much of the energy resources of females are tied up with reproduction, either while producing eggs or during mouth brooding; this means that the growth rates of males are much higher than females.
- Males make nests and attract ripe females to the nest with courtship displays.
- The female lays eggs in the nest, where they are fertilized by the male and immediately picked up in the mouth of the female.
- Males will continue to court other females, while the female that has just spawned retreats away from the nest to incubate the eggs.
- Males play no part in parental care and can mate with many females at a time; therefore sex ratios in breeding ponds can be as high as seven females to one male.
- Eggs hatch in the mouth of the female after about five to seven days (depending on temperature) and the hatchlings remain in the mouth while they absorb their yolk sacs.
- Tilapia fry start swimming out of the mouth to feed, but return to the mouth at any sign of danger. Once the fry have become too large to fit in the female's mouth, they become totally independent and move to warm, sheltered water such as near the edge of a pond.
- Tilapia eggs are relatively large, producing large fry.
- Removing the eggs or fry from a brooding female prematurely will increase the frequency at which the female will spawn.
- Eggs are stimulated to develop once the previous batch of offspring is released, so a female will return to spawn after a recovery period of four weeks or less.
- Typical brood sizes are 100-500 fry; larger females have bigger broods.

Husbandry techniques

- Earthen ponds are prepared for stocking in the standard manner for the semi-intensive culture of warmwater fish (see Section 4.1 of this manual).
- Fingerlings of 10-20 g are stocked and cultured for a full production cycle (five to six months with fertilization and feeding).
- Stocking rates range from two to six fingerlings/m², depending on the level of management.
- Male tilapia are known to grow almost twice as fast as females. It is therefore preferable to stock only males (monosex culture) to achieve the fastest growth and reach market size in the shortest possible period of time, resulting in more protein and profit for the farmer.
- When the fish have reached market size, ponds are partially drained and seines are used to remove the fish. The last fish are removed by fully draining the pond.

Production of all-male fingerlings

As mentioned above, male tilapia are known to grow more quickly than females, making it desirable to stock ponds only with males whenever possible. All-male populations can be produced by at least two practical methods, hand sexing and hormonal sex reversal. Each method has advantages and disadvantages. Hand sexing is cheaper and does not require special materials or technology, but it does require that farm workers be able to distinguish males from females without error at a fairly small size (approximately 20 g), so that no females will be accidentally stocked into a pond. Hormonal sex reversal, on the other hand, requires special training to prepare hormone-containing feeds and to administer these feeds on a precise schedule during the first few weeks after hatching. Additional details about these two methods are given in Section 5.2, "Tilapia seed production."

Tilapia rearing systems in ponds

- Extensive culture systems are the least productive. These are usually earthen ponds with low input and minimal management, uncontrolled breeding, and irregular harvesting; yields in this type of system are typically 500-2,000 kg/ha/yr of uneven-sized fish.
- The next system up is manured ponds with uncontrolled breeding and regular harvesting; yields are typically 3,000-5,000 kg/ha/yr of uneven-sized fish.
- Higher yields can be realized in semi-intensive systems, which require much greater investment in terms of management and stocking. If monosex fish are stocked and regular manuring and supplementary feeding is practiced, yields can be up to 8,000 kg/ha/yr of even-sized fish.
- It is quite common for tilapia to be grown in polyculture ponds with catfish or other predatory fish.

- The main advantage of growing tilapia in ponds is that they can be grown very cheaply through fertilization.
- Higher yields can be achieved by stocking monosex fish and using nutritionally complete feeds.

Current issues of interest to tilapia farmers

A major management problem of pond-cultured tilapia is excessive reproduction and the subsequent stunting of fish due to overcrowding. Methods of controlling overpopulation include manual sexing of fish, use of sex-reversal hormones to produce all males, and use of predators. The success of these methods may rest with how well a fish farmer understands the techniques.

At the same time, another constraint in Kenya is the unavailability of sufficient quantities of high-quality fingerlings for pond stocking. There is need for fingerling production centres or hatcheries that can produce tilapia fingerlings in large numbers. Farmers should be encouraged to venture into the production of fingerlings as an enterprise and become fingerling suppliers for other farmers.

A third constraint is a lack of fish feeds, which are needed to increase fish growth rates, pond productivity, and income from the pond.

Moving on

This section has outlined some of the characteristics of Nile tilapia and provided some basic information about its culture. In the next section, the characteristics and culture of the African catfish will be considered.



Figure 3.1-2. Young male and female tilapia (*Oreochromis niloticus*) can be distinguished when they reach about 20 g in weight. On males (left) the genital papilla is larger and more distinct than on the female (right).

3.2: AFRICAN CATFISH

Introduction

Demand for African catfish (*Clarias gariepinus*), both for food and as bait in capture fisheries, has been increasing substantially in Kenya in the last few years. The Fisheries Department estimates that for aquaculture activities, there is a demand of about 10 million catfish fingerlings per year, while the demand in the Lake Victoria capture fisheries is about 18 million fingerlings per year. This adds up to a total demand of about 28 million catfish fingerlings per year.

Catfish generally reach maturity at two years of age at a weight of 200-500 g. Females can produce between 10,000 and 150,000 eggs, depending on the size and age of the female. The yolk sac is almost completely absorbed two to three days after hatching and feeding begins at this time. The main first foods are zooplankton and small aquatic insect larvae. However, development is temperature dependent and some fry have been known to start feeding after their fourth day. By eight to ten days, they can be weaned onto a formulated diet consisting of fish meal and bran from cereals. Inadequate nutrition, poor water quality, and overcrowding are three major factors that often contribute to poor spawning results.



Figure 3.2-1. African Catfish, *Clarias gariepinus*

Temperature tolerances

- Temperature is the most important variable affecting the growth of larvae and early juveniles.
- The optimal temperature for growth appears to be 30°C; however, temperatures in the range of 26-33°C are known to yield acceptable growth performance.
- At temperatures below this range, growth rates decrease but survival is still good. However, 28°C is the optimal temperature for both yolk sac absorption and maximum growth rate.
- High temperatures can encourage the growth of harmful bacteria and fungi, however.

Tolerance of low dissolved oxygen (DO) concentrations

Catfish can withstand very low dissolved oxygen levels, but well-oxygenated water is recommended. This is easily achieved by means of aeration or good flow rates.

Salinity tolerance

- A salinity range of 0-2.5 parts per thousand (ppt) appears to be optimal for young catfish.
- Larval growth is acceptable in up to 5 ppt salinity, and survival is good up to 7.5 ppt.

Light (Photoperiod)

- Optimal survival is achieved when larvae are reared in continual darkness, and larval growth decreases with longer periods of light.
- The free-swimming embryos (hatchlings) shy away from light and are said to be photophobic. They form aggregations on the bottom of the incubation tank.
- Taking advantage of their photophobic behaviour, it is possible to concentrate them in a dark corner of the tank and to remove both deformed and weak hatchlings using a siphon.

Reproduction in the natural environment

- In nature, African catfish are known to exhibit a seasonal maturation of gonads usually associated with the rainy season.
- The onset of maturation is influenced by changes in temperature and photoperiodicity.
- Final maturation and spawning are triggered by a rise in water level and flooding of marginal areas resulting from rainfall.
- In eastern Africa, reproduction usually begins in March, with the start of the long rains, and ends in July.
- Spawning usually takes place at night in shallow areas of lakes, streams, or rivers. Courtship and mating between male and female pairs is aggressive.
- The pair usually mates, then rests for a few minutes, and then resumes mating again.
- Catfish do not exhibit parental care except for the careful selection of mating site.

Nutrition and growth

- Catfish are omnivorous or predatory, feeding mainly on aquatic insects, fish, crustaceans, worms, molluscs, aquatic plants, and algae.
- They find food by probing through the mud on the bottom of the ponds.
- Their nutritional requirements in fish ponds (particularly for protein and lipids) are highly variable, and are influenced by factors such as management practices, stocking densities, availability of natural foods, temperature, fish size, daily feed ration, and feeding frequency.

- Zooplankton become more important as a diet item with increasing fish size and predominate in the diets of larger fish.
- At hatching, catfish larvae measure 5 to 7 mm in length and weigh between 1.2 and 3.0 mg.
- The larvae begin feeding two to four days after hatching, depending on the temperature, before the yolk sac is completely absorbed, and food must be offered to them at this time.
- Food given to catfish larvae should have 50% protein and 10-15% lipid content.
- The stomach is completely functional after five days of feeding, marking the end of the larval period.

Spawning and fingerling production

- For catfish culture, spawning is usually done artificially, by hormone injection.
- Seed production therefore usually requires maintenance of a broodfish conditioning pond and the use of a small hatchery for spawning and nursing the young fish.
- For further details on spawning and early rearing of larval catfish, refer to section Section 5.3, "Catfish seed production."

Pond culture of catfish

1. Pond preparation

- Ponds should be properly prepared prior to stocking so that natural foods are abundant and the presence of predators is minimized. See Section 4.1 ("Preparing your fishpond for stocking") to see how to best fertilize ponds prior to stocking.
- In general, the use of organic fertilizers (manures and composts) results in the fastest development of zooplankton blooms in ponds.
- See also the section on "Preventing fish diseases and controlling predators."

2. Stocking levels

- When stocking hatchery-started fry into nursery ponds, stock at a rate of 100-450 fry per m³.
- When stocking fry into hapas in ponds, stock at a rate of 100 fry per m³.
- When stocking catfish in tilapia ponds as a way to control unwanted tilapia reproduction, stock approximately 10% of the number of tilapia stocked, i.e., for every 100 tilapia stocked, add about 10 catfish. Note that the difference in the sizes of tilapia and catfish stocked is critical; refer to Section 4.2 for further details.
- When stocking catfish fingerlings to rear them for the market, increase the stocking rate to about 2 to 10 per m². For a 6- to 9-month growing period, these rates will produce fish of about 500 g and 200-250 g, respectively, depending on water temperatures.

3. Pond management through the culture period

Manage the pond as discussed in the sections on “Preparing your fishpond for stocking,” “Feeding your fish,” and “Managing pond water quality.”

Current issues of interest to catfish farmers

A major challenge to catfish producers is high mortality rates of fry resulting from starvation, cannibalism, disease, and predation during the hatchery and nursery phases of production. Provision of an acceptable feed during this critical period is the most important factor affecting the survival of catfish fry.

Moving on

This chapter has provided some basic information about the characteristics and culture of the two most popular pond fish in Kenya, the Nile tilapia and the African catfish. The next chapter provides a step-by-step overview of the management practices needed for the efficient production of these two species in earthen ponds.

CHAPTER 4: FISHPOND MANAGEMENT

In fish farming enterprises, efficient operation and high production can only be achieved if ponds are properly managed. Management activities begin with the preparation of the pond for the fish crop and continue with stocking and feeding the fish, ensuring that water quality remains high throughout the culture period, taking measures to prevent invasion by predators and the occurrence of diseases, and harvesting the fish. An important ancillary management practice that should never be overlooked is keeping good records of expenses and income and of all activities and events associated with the pond or farm, so that this information can be used to improve operations in the future.

4.1: PREPARING YOUR FISHPOND FOR STOCKING

Introduction

Prior to stocking your fishpond, whether it is a newly constructed pond or is a pond that you have just harvested, there are certain things you should do to prepare the pond for the next crop of fish. Follow the steps below to properly prepare your pond for stocking.

Preparing your pond for stocking with fish

1. For an old pond, drain all water from the pond and allow it to dry for a period of fourteen days.



Figure 4.1-1. Drying the pond bottom helps kill potentially harmful organisms in the soil and speeds the breakdown of excessive organic matter (a beneficial process) that remains after previous crops of fish.

2. Apply lime to the pond bottom and dyke slopes.

- You should always choose agricultural limestone (CaCO_3) for application in your fishpond. If agricultural limestone is not available in your area, please consult your fisheries officer or extension agent about the possible use of other liming materials, e.g., quick lime or slaked lime.
- Apply the amount of agricultural limestone shown in Table 4.1-1, depending on either the total alkalinity of the pond water or the pH of the soil.
- If unsure of the alkalinity or soil pH of your pond, start by using the lowest recommended amount from this table, i.e., apply 1,000 kg of limestone per hectare of pond surface area until pH or alkalinity can be determined.
- If the pond is located in a dry area, that is, one with little rainfall (<500 mm/yr), it may be unnecessary to lime it.
- Distribute the powder evenly around the pond bottom and on the slopes of the dykes. This can be done using a shovel. Always wear

Table 4.1-1. Amounts of lime to apply to ponds according to the pH of the pond bottom soil or the alkalinity of the pond water. When neither pH nor alkalinity is known, use the lowest rate shown on the table (1000 kg/ha) until pH or alkalinity can be determined.

Total Alkalinity (mg CaCO ₃ /L)	Soil pH	Apply this amount of limestone	
		kg/ha	g/m ²
<5	<5	3000	300
5–10	5.0–5.4	2500	250
10–20	5.5–5.9	2000	200
20–30	6.0–6.4	1500	150
30–50	6.5–7.0	1000	100

gloves when working with any kind of lime.

- If necessary, you can also apply lime by spreading it over the water surface after filling the pond.

3. Apply organic fertilizer to the pond before filling it with water.

- Determine which organic fertilizers are readily and cheaply available in your area. The most common examples of organic fertilizers are animal manures (e.g., from cattle, poultry, donkeys, rabbits, sheep, goats) and decaying plant matter, such as cut grasses.
- Apply available animal manure to your fishpond at a rate of 50 g of dry matter per m² per week. This is equivalent to 5 kg/100 m²/week.
- Apply the manure to your pond in one of the following ways:
 - ♦ Spread dry manure on the pond floor before filling with water.
 - ♦ Spread (broadcast) dry manure on water surface periodically.
 - ♦ Place dry manure in a crib or compost bin in a corner or along the side of the pond, as shown in Figure 4.1-3.
 - ♦ Set sacks filled with manure to float within the pond and shake them daily to allow nutrients to leach out and enhance water fertility.
 - ♦ Construct poultry houses or pig pens above or adjacent to ponds to facilitate easy movement of the manure to the fishpond. See Section 1.2 of this manual to learn more about integrating fish culture with other activities on your farm.
- Apply plant matter in one of the following ways:
 - ♦ Combine dead plant material with animal manure to form compost, which can then be applied into pond waters.



Figure 4.1-2. Applying lime to the pond bottom and sides.



Figure 4.1-3. Placing compost in bins or cribs is one way to provide nutrients to fish ponds.



Figure 4.1-4. Building poultry houses over the edges of ponds is another way of fertilizing them.

- ◆ These materials can also be mixed as compost heaps in cribs in a corner or along the side of the pond.
- ◆ Hay and other grasses can also be spread over the pond water as fertilizers.
- Repeat applications of organic fertilizers at these rates on a weekly basis throughout the fish rearing period.

4. Fill the pond with water.

5. Apply inorganic fertilizer to the pond after it has been filled.

- Inorganic fertilizers, sometimes called “chemical” fertilizers, are manufactured from mineral deposits for use in land agriculture. They are usually available from farm input shops in 50- or 100-kg bags. Inorganic fertilizers commonly used in fishponds in Kenya are Di-Ammonium Phosphate (DAP) and UREA.
- Apply DAP and UREA to your fishpond at the following rates:
 - ◆ DAP: 2 g/m²/week (or weekly applications of 15 tablespoons DAP for every 100 m²)
 - ◆ UREA: 3 g/m²/week (or weekly applications of 30 tablespoons urea for every 100 m²)

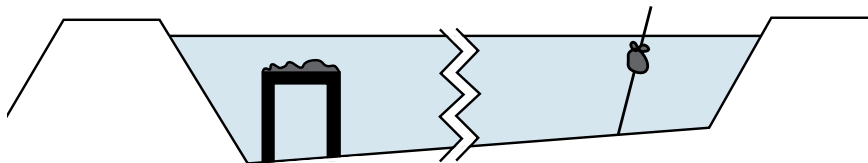


Figure 4.1-5. Inorganic fertilizers can be placed on a small platform or in a small, porous bag suspended from a stick (the stick is anchored in the pond bottom). In either case, the fertilizer should be placed near the water surface to keep it from interacting with the pond soil.



Figure 4.1-6. Inorganic fertilizers can also be dissolved in water and broadcast over the pond surface.

- Apply inorganic fertilizers to your pond using one of the following methods:
 - ♦ Dissolve the fertilizer in a bucket of water by stirring with a stick and then sprinkle the solution around pond.
 - ♦ Place small mesh bags of fertilizer on platforms just under the water surface in the pond, where the material can slowly dissolve and become available to phytoplankton.
 - ♦ Suspend small bags of fertilizer from stakes just under the water surface.
- Do not apply inorganic fertilizers directly to the pond bottom, because important nutrients may be absorbed by the mud and not be available to benefit your pond.
- Plan to continue applying fertilizers to your pond at the given rates on a weekly basis throughout the culture period.
- Avoid applying too much fertilizer to your pond, however, as this can lead to water quality problems as well as higher costs for you.

Moving on

When you have completed the above steps your pond is ready for stocking with fingerlings. Refer to the next section for the proper stocking rates and instructions for the safe transfer of fingerlings into your pond.

4.2: STOCKING YOUR FISHPOND

Introduction

To get a good crop of marketable fish it's necessary to stock the pond with the correct number of fingerlings. Stocking too few fish may result in fast growth and large fish but this isn't an economical use of the pond. However, stocking too many fish will result in slow growth and a large number of very small fish.

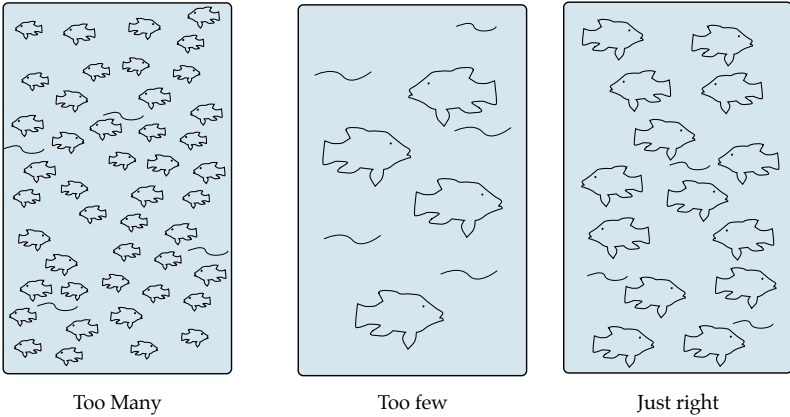


Figure 4.2-1 Left: Stocking too many fish results in a large number of very small fish. Center: Stocking too few fish results in a few very large fish, but the pond space is not fully utilized and more fish could have been produced for the same cost. Right: Stocking just the right number gives many large, marketable fish.

Stock your ponds or tanks with the following numbers of fish:

Tilapia

- For all-male (monosex) culture of tilapia for the market, stock fish of 20-40 g size in properly prepared ponds at a density of 1-2 fish per m².
- If only mixed-sex tilapia are available to you, stock them as you would all-male fingerlings (i.e., at 1-2 fish per m²), but stock catfish fingerlings along with them. For every 1000 tilapia fingerlings stocked you should stock 50-100 catfish fingerlings (5-10% by number). At the time of stocking, the tilapia fingerlings should be four times bigger than the catfish fingerlings so that they cannot be eaten by the catfish. Later the catfish will help control the tilapia population by consuming small tilapia that begin to appear when the tilapia you originally stocked reach spawning age (about 3 months).
- If you plan to rear tilapia fry to fingerling size, either for further stocking or for hand sexing, stock 1-3 g fish in properly prepared nursery ponds at 10 fish per m².

Catfish

- If you are stocking catfish fingerlings to rear to market size, stock them at a density of from 2 to 5 per m². Stocking with the lower number (2/m²) should give you fish of up to 500 g each after 6-9 months of culture. Stocking at the higher density will give you smaller fish over the same rearing period, resulting in perhaps 200-250 g fish, depending on water temperatures and the amount of care you give to the pond.
 - ♦ For nursing to fingerling size, stock catfish fry in tanks or aquaria at 50-150 fry/L. Nurse them in the aquaria or tanks for at least 14 days and then move them out to ponds or hapas, and stock at a density of 100 fry/m² and rear them for another 35-40 days.

Follow these guidelines for safe handling and movement of fish:

- Stop feeding your fish one to two days prior to moving them.
- Handle fish only during the cool parts of the day, preferably early in the morning.
- Use seines and dipnets manufactured from the softest netting material possible to minimize abrasion to your fish.
- Periodically inspect your tubs, dipnets, buckets, and other fish handling equipment to be sure there are no sharp edges or corners that can injure the fish.
- Keep fish in water during all stages of moving from one place to another.
- Do not crowd the fish too closely in seines, dip nets, tubs, or transport tanks.
- Move fish to their next location as quickly as possible; do not leave tubs or buckets of fish out on the pond bank for a long time, especially on hot days.
- When putting the fish into a pond, take some time to equalize the water temperature in the transfer container (plastic bag, bucket, tub, etc.) with that of the pond water. This can be done by floating the transfer container in the pond water for approximately 15 minutes prior to releasing the fish.
- You can also gradually mix the pond water into the transfer container; this has the advantage of equalizing not only the water temperatures but also other water chemistry differences that may exist.
- Whenever possible, provide a spray or gentle flow of clean, fresh water to fish that are crowded together during handling.
- Clean all of your fish handling equipment thoroughly after each use. This can be done by thoroughly rinsing it in clean water, picking all debris, fish, or other materials out of it, and drying it briefly in the sun. This helps preserve your equipment and minimize the spread of fish diseases.



Figure 4.2-2. Plastic fish transportation bags should be floated in the pond long enough to equalize water temperatures prior to releasing the fish.

Moving on

Now that you have properly prepared and stocked your pond, you are ready to settle in to the daily fish farming routine of monitoring, feeding, fertilizing, managing water quality, controlling predators, sampling your fish, and so forth, right up to the time of harvest.

4.3: FEEDING YOUR FISH

Introduction

You can increase the productivity of your pond and speed up the growth of your fish by providing them with supplemental food, i.e., prepared feeds they can consume in addition to the natural foods they find in the pond. This is one way of intensifying your fish production system. Refer to Section 4.8 if you are interested in other ways of intensifying production.

Feeds for fish

Manufactured fish feeds are not widely or readily available in East Africa. Exceptions exist where larger commercial operations such as TamTrout produce their own feeds for their own fish and may have excess quantities available for sale. Where manufactured feeds are available, they might be found in one or more of the following forms:

- Meal
- Crumble
- Dry sinking pellets
- Moist sinking pellet
- Floating pellet

Several different diet formulations have been tested at Sagana Aquaculture Centre, with the most effective formulation having the following composition:

Cottonseed cake	37%
Wheat bran	57%
Freshwater shrimp (<i>Caradina</i> spp.)	6%
Vitamin mix	minimal

Some farmers are successfully using feeds they have mixed for themselves. Examples of mixes that are easily prepared and economical to use include:

- Mixture of 76% rice bran and 24% fish meal
- Mixture of dried freshwater shrimp (*Caradina* spp.) and maize bran, sometimes with some omena meal added



Figure 4.3-1. Good feeds can easily be prepared at the farm by mixing ingredients such as corn bran and ground freshwater shrimp

Feed processing usually includes a number of steps, including grinding, mixing, binding together, fat coating, drying/cooling, crumbling, and bagging. In the East African region, most on-farm feed preparations are made in small quantities, using improvised machinery that is operated either manually or mechanically, with outputs of not more than five 90-kg bags daily.

Feed ingredients can be hand ground or a manual grinder can be used. The ingredients are then mixed in a hand-operated mixer. After preparation, feeds can be made into pellets using a pelleting machine.



Figure 4.3-2. A hand-operated mixer is used to mix feed ingredients at Sagana Aquaculture Centre.



Figure 4.3-3. A simple pelleting machine is used to prepare fish feeds on the farm at Sagana Aquaculture Centre.

Storage of feeds

To ensure good quality and palatability, fish feeds should be stored in cool and dry stores. Avoid buying excess feed that may expire before its use.

How much to feed your fish

You must know how many fish you have in your pond to properly calculate how much feed to give them. You will have a good idea of the number of fish present if you properly prepare the pond for stocking (Section 3-1), know how many fish were stocked, and make frequent observations of the pond to know whether or not fish have died. Refer to Table 4.3-1 to determine the amount of feed you should give your fish each day.

- These amounts can be used for ponds stocked with tilapia or ponds with both tilapia and catfish (polyculture).
- These amounts can be fed all at once or divided into two equal portions given in the morning and in the evening.
- For better feeding efficiency, weigh a representative sample of your fish every second week, using their actual weight to determine the amount to feed rather than an assumed weight.

Table 4.3-1. Daily feed rations (per fish), determined either according to the time since stocking or the present size of the fish. The amount of feed shown should be multiplied by the number of fish present in the pond.

Time since stocking (months)	Assumed size of fish (grams)	Amount to feed per day*	
		Wheat bran	Pelleted diet (26% protein)
1-2	5-20	1 g/fish	1 g/fish
2-3	20-50	1-3 g/fish	1-2 g/fish
3-5	50-100	3 g/fish	2 g/fish
5-8	100-200	4 g/fish	3 g/fish
8 or more	Over 200	5 g/fish	3-4 g/fish

*using supplementary feed at Sagana, e.g., bran and a diet of 26% protein

In the beginning throw out small amounts of feed at a specific time of the day and observe the response. After the fish have accepted the prepared feed and learned when and where they will receive it they should become very enthusiastic feeders. Normally fish take about 15 minutes to consume the food.

You should be prepared to reduce the amount fed per day when one or more of the following occur:

- Fish are clearly not consuming their normal amounts of feed
- Water temperatures are noticeably higher than normal for the time of year
- Dissolved oxygen levels are low

All of the above may occur simultaneously when you are nearing the end of a production cycle, especially if the planned harvest time is during the hot months.

When to feed your fish

Keep the following points in mind while deciding when to feed your fish each day:

- Tilapias have small stomachs and often browse all day long.
- The best time to provide supplementary feed is between 10 a.m. and 4 p.m., when the water temperature and dissolved oxygen are reasonably high.
- It is advisable to feed from the same position and time each day for each pond. The fish soon learn when and where they can expect a good meal.
- The feeder must be a reliable and dedicated person.

How to feed your fish

Some of the ways fish feed can be offered to fish include:

- Broadcast the feed into the water as you walk along the pond bank.
- Place the feed on a feeding platform or table under the water.
- Use a demand feeder, which releases fish food when the fish bump a lever.
- Use an automatic feeder, which releases or broadcasts feed at pre-determined times.
- Neither the demand feeder nor the automatic feeder requires that an attendant be present at feeding time, but both need to be refilled regularly and periodically checked to be sure they are operating properly.

A benefit of feeding by hand is that the feeder has the opportunity to observe how well the fish are feeding, as well as how fast they are growing. Healthy fish usually eat enthusiastically, and any deviation from enthusiastic eating suggests a problem may be developing. The following are some reasons why fish such as the Nile tilapia may not feed as well as expected.

- The water is too cold.
- The dissolved oxygen level is too low.
- The fish may have died.
- The fish are ill.
- The feed is very heavy and sinks so fast you do not see the fish eating it.



Figure 4.3-4. Dry, powdered feeds can be broadcast onto the pond surface.

Summary on fish feeding: “Four Fixes:”

- **Fixed feed quality:** Feed should be fresh and palatable with a high nutritive value. Spoiled food should be thrown out to prevent disease.
- **Fixed feed quantity:** Fish should be provided with a fixed amount of feed every day. Uneven feeding causes poor digestion, poor absorption, and slow growth..
- **Fixed feeding time:** Feeding should be around 10:00 am and 4:00 pm.
- **Fixed feeding location:** Feed should be given at the same place at each feeding, e.g., on a feeding platform.

Moving on

Whether or not feeding is part of your pond management scheme, you should carefully monitor the condition of your pond on a daily basis, paying particular attention to water quality and fish behaviour. The next section describes some of the most important water quality concerns faced by pond managers and provides suggestions on how to prevent problems from developing.

4.4: MANAGING WATER AND SOIL QUALITY IN YOUR POND

Introduction

Good water quality must be maintained if fish are to remain healthy, grow well, and give you a good crop in a reasonable amount of time. To maintain water quality, farmers must monitor pond conditions every day, taking note when things do not appear normal or if fish are behaving in unusual ways. Following are some water and soil quality characteristics to be concerned with and some methods to ensure that pond conditions remain good.

Dissolved Oxygen (DO)

Your goal should be to keep DO at 3 mg/L or higher for tilapia and catfish by:

- Promoting and maintaining a good phytoplankton bloom through fertilization; however, do not overfertilize your pond.
- Stocking your fish at the recommended rates.
- Feeding your fish at the recommended daily rates and avoiding overfeeding, which wastes feed and may compromise DO levels.
- Reducing feeding rates during cloudy weather, periods of slow growth, or when water temperatures are unusually high.
- Running bubbling fresh water into your pond in emergency situations; if possible, simultaneously release oxygen-poor water from near the bottom of the pond.



Figure 4.4-1. Low levels of oxygen can lead to sudden, massive fish kills.

Plankton Turbidity

Maintain a plankton density (“bloom”) that allows you to see about 30-45 cm into the water (The depth where you can just see the palm of your hand if you extend your arm into the water up to your elbow). This can be achieved by:

- Fertilizing the pond at recommended rates prior to stocking, and as needed during the fish production cycle, to maintain the plankton bloom.
- Checking visibility frequently during the culture period and taking necessary actions before problems arise:
- In case of low visibility, physically remove excess plankton.
- If visibility is high, apply additional fertilizer.

Alkalinity and Hardness

It is desirable to maintain both alkalinity and hardness at 40-70 mg CaCO₃/L. This can be done by:

- Where water is “soft” or acidic and soils are acid, apply lime (agricultural limestone) to the pond soil at recommended rates prior to filling the pond (see Section 4.1).
- Lime is usually applied to the soil prior to filling the pond; however, it may be added after filling by spreading it uniformly over the water surface.
- In areas where soils are alkaline and hardness and alkalinity are high, application of lime is not required.
- Note that these methods are the same as those used for managing water pH; indeed proper management of hardness and alkalinity will usually eliminate the need to worry about pH.

pH

The pH of pond waters should be maintained between the optimum limits for fish, i.e., between 6.5 and 9.0. This can be achieved by:

- Maintaining alkalinity at or above 40 mg CaCO₃/L so that pH does not fluctuate widely.
- Applying lime (agricultural limestone) to the pond soil at recommended rates in regions where water and soils are acidic. Note that in areas where soils are alkaline and hardness and alkalinity are high, application of lime is not needed.

Ammonia

Un-ionized ammonia (NH₃) concentrations in pond water should be kept below 0.5 mg/L. Concentrations of this form of ammonia, which is toxic to fish, are influenced by DO, pH, and alkalinity, so it essential to manage these parameters as explained above, including:

- Keeping pH near neutral, and at least below 9.0.
- Keeping DO concentrations high.
- Maintain water alkalinity at 40 mg CaCO₃/L or above.

Pond Fertility

Ponds should be provided with adequate supplies of the nutrients needed by pond organisms to ensure good health, reproduction, and fast growth of the fish. This can be done by:

- Liming and fertilizing the pond at the correct rates, as described above and in Section 4.1.
- Monitoring phytoplankton density using a Secchi disk or your hand and adjusting fertilization accordingly.

Clay Turbidity

Clay turbidity in pond water (muddy water) can be harmful to fish and limit pond productivity. Minimize clay turbidity in pond waters by:

- Using a diversion canal to divert muddy water around the pond.
- Treating turbid ponds with animal manures at rates of 2.4 T/ha every three weeks.
- Treating turbid ponds with lime (agricultural limestone), using rates recommended for improving soil pH and water alkalinity.
- Avoiding stocking species that stir up pond bottom mud.

Toxic Materials

Pond managers must ensure that substances toxic to fish and other organisms (herbicides, insecticides, and other chemicals) are kept out of the pond. Some methods for protecting the pond from toxic substances include:

- Not using insecticides, herbicides, or other chemicals (except for recommended inorganic fertilizers) in or near your pond.
- Not allowing runoff from nearby agricultural fields to enter the pond.
- Not spraying agricultural crops near fish ponds on windy days.

Water Temperature

As much as possible, water temperatures should be maintained within the optimum ranges of the species being farmed. Although it is generally difficult to control water temperatures in ponds, some ways to ensure that temperatures are suitable for the species being farmed include:

- Stocking species whose optimum temperature ranges match the temperature of the water available at your location.
- If sources of water with different temperatures are available, adjusting pond water temperatures by adding cooler water to lower the temperature.

Soil pH and Acidity

Ensuring that soil pH and acidity are within acceptable limits is a necessary part of managing the alkalinity, hardness, and pH of the water, which were discussed above. The key is to keep soil pH at 6.5 or above, which will usually maintain water pH, hardness, and alkalinity at desirable levels. Soil pH can be kept at the right level by:

- Drying the pond for at least two weeks after each harvest before refilling and restocking.
- Applying lime (preferably agricultural limestone) to the pond after each harvest. Normally lime should be applied to the pond bottom before it is refilled, but if necessary, it can be applied to the water surface after filling the pond. Only recommended liming materials and application rates should be used (Refer to Section 3.1).

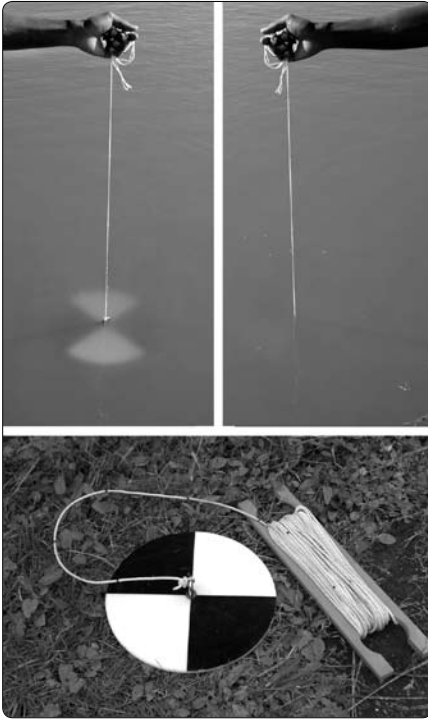


Figure 4.4-2. A Secchi disk is used to estimate phytoplankton density and the fertility of a pond. If you can still see the disk when it is lowered beyond 45 cm, then the pond should be fertilized. If the disk disappears at a depth much less than 30 cm, then the pond is too fertile.

Moving on

In addition to monitoring and maintaining good water quality in your pond, take measures to ensure that diseases and predators do not become a problem. The next section outlines some potential problems and some methods for prevention.



Figure 4.4-3. If you do not have a Secchi disk, you can use your hand to check visibility (phytoplankton density, fertility) in a pond.

4.5: PREVENTING FISH DISEASES AND CONTROLLING PREDATORS

Introduction

In East Africa fish diseases are not common on fish farms due to the low rates at which fish ponds are stocked and the relative hardiness of the fish that are usually farmed here, e.g., tilapia and African catfish. The term “disease” may refer to any “illness” of fish, as evidenced by changes in their appearance and/or behaviour and perhaps by death. As with humans, diseases of fish usually result from exposure to excessive stress in the environment, which lowers their resistance to disease organisms. Common sources of stress for fish include:

- Poor nutrition
- Poor sanitation and environmental conditions
- Overcrowding in ponds
- Rough handling of fish by farm workers
- Presence of disease vectors and intermediate hosts

Signs of stress, parasites, and disease

Monitor your fishpond and observe the behaviour of your fish at least daily, looking for any of the following signs of stress and/or disease:

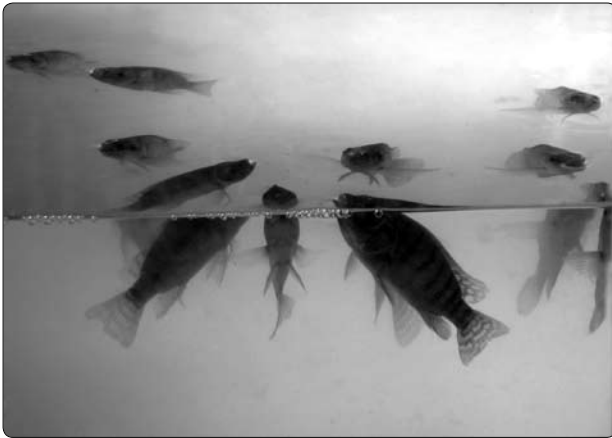


Figure 4.5-1. When fish are seen “piping” at the water surface or crowding around a water inlet, oxygen levels in the pond are probably low.

- Many fish “gulping air” (“piping”) at the water surface
- Large numbers of fish crowding around an inlet of freshwater
- Loss of appetite by fish
- Individual fish swimming erratically and apart from the rest
- Individual fish of unusual colouration—often very dark in appearance
- Individual fish swimming in circles (“whirling”)
- Retarded growth
- Distended stomach

- External parasites visible on the fins, body (perhaps protruding from under scales), or gills of fish; parasites (worms) visible on/in internal organs
- Excess mucus on skin
- Cotton- or wool-like growths (fungus) on the skin surfaces
- Peeling skin, ulcers, lesions, and erosion of fins.



Figure 4.5-2. External parasites protruding from between the scales of a fish.

Examples of extreme or advanced cases of disease or parasite infestations include:

- White lesions on the head, back, and gills
- Hemorrhagic ulcers on body or on internal organs
- Deep ulcers extending into muscles
- Internal bleeding and kidney damage or anemia
- Sloughing away of gills and excessive slime
- Fish deaths increasing over time

Symptoms such as anemia, anorexia, bone deformations, and cataracts or cloudy lenses (in the eyes) may sometimes appear, but these generally suggest nutritional deficiencies rather than actual diseases or parasite infestations.

Preventive measures

Practice the following measures to reduce stress and avoid the development of parasites and diseases in your fishpond:

- Dry your pond after each culture cycle.
- Apply lime to your pond soil as a preventive measure, even if you do not need it to manage soil pH or water alkalinity.
- Keep weeds cut back in and around your pond.
- Control populations of birds, reptiles, snails, frogs, and wild fish around your fishpond.
- Stock only with healthy fish obtained from a known source — inspect fish purchased for stocking before taking delivery of them.
- Quarantine any fish exhibiting strange behaviour or an unusual appearance.

- Always handle fish carefully and only when necessary.
- Don't stock more than the recommended number of fish in your pond.
- Maintain a regular feeding schedule and avoid wastage of feed (overfeeding).
- Maintain good pond sanitation.
- Avoid feeding your fish with moldy or spoiled feed.
- Remove and examine dead fish as soon as possible.

If you suspect that a disease or parasite problem is developing in your pond, it would be prudent to consult your fisheries extension office for advice.

Controlling predators around your pond

Predators, especially birds such as kingfishers, pelicans, and herons, can cause massive crop losses for you, perhaps without you even knowing there is a problem until you harvest your fish. Other predators that can cause damage include monitor lizards, frogs and tadpoles, snakes, turtles, and carnivorous fishes. For very young fish (larvae or fry), even aquatic insects and insect larvae can be serious predators. Some basic steps to minimize these problems include:

- Keep grasses on dykes and around ponds cut low.
- Install covered hapas in your pond for rearing very young fish, e.g., catfish fry.
- Construct a low barrier around ponds to keep small land animals out.
- Stretch netting over ponds to keep birds out.



Figure 4.5-3. Low barriers can be put up around ponds to keep predators out.



Figure 4.5-4. Netting can be stretched over ponds to keep predators out.



Figure 4.5-5. Birds such as herons and egrets can remove significant numbers of fish from a farmer's pond.

Moving on

Regular monitoring of your pond and fish will help you identify potential problems early and prevent the development of full-scale disease or parasite problems. By preventing such problems you are more likely to have a large crop of healthy fish at harvest time.

4.6: HARVESTING YOUR FISH

Introduction

Good farming practices include regular harvesting of the crop to earn the farmer an income. The frequency of harvests and the quantities and returns realized are key indicators of the economic viability of the enterprise. With good management, as described in the preceding sections, your fish should be ready to harvest within six to nine months after stocking. By this time, tilapia should have reached a size of approximately 250-300 g and catfish a size of 250-500 g, depending on their size at stocking, the density at which they were stocked, and water temperatures during the growing period.

Preparing for the harvest

- Make marketing arrangements well in advance of the harvest date.
- Plan to harvest your fish early in the morning or early in the evening.
- Stop applying fertilizers one to two weeks prior to harvesting.
- Stop feeding the fish two days before harvesting.
- Set up all harvesting and transportation equipment well in advance. Contact fisheries personnel if you need guidance to acquire the right equipment for harvesting.
- Prepare the manpower.
- Partially drain the pond very early in the morning on the day of harvest.



Figure 4.6-1. Harvesting equipment assembled on the pond bank prior to beginning the harvest.



Figure 4.6-2. Harvesting fish with a seine net.



Figure 4.6-3. Using poles to hold up a seine in a pond.

The harvest:

Most earthen pond harvesting is done with a seine.

- Seine early in the morning, while the weather is still cool.
- Begin seining in the shallow end of the pond and work towards the deep end.
- Work carefully, disturbing the pond bottom as little as possible.
- If possible, finish the seine haul near a water source in the deep end.
- Loosen the seine somewhat to avoid crowding the fish too much during handling.
- Long, forked sticks can be used to hold up the top of the seine.
- If possible, spray a stream of fresh water over the fish while they are being held and handled.
- Gradually lower the water as you near completion of the harvest.
- Use a dipnet to move fish from the seine to buckets on the pond bank.
- Use cast nets, lift nets, hoop nets, or gill nets for harvesting if ponds are too deep or are not drainable, or if you do not have a seine.

- Fish can be marketed dead or alive. Always handle live fish with extreme care, stressing them as little as possible.
 - ♦ Keep the fish in fresh water at all times.
 - ♦ Move fish into less-confined holding tanks as soon as possible
 - ♦ Transport them to the market as soon after harvest as possible.
 - ♦ If possible, provide aeration for live fish during transportation.



Figure 4.6-4. If flowing water is not available at the deep end of the pond then a bucket can be used to provide fresh water for fish being harvested.



Figure 4.6-5. With good management you can produce high-quality products for the market.

Moving on

When your harvest is complete, you are ready to prepare the pond for another crop of fish. Refer back to the first section in this chapter to review the necessary steps.

4.7: INTENSIFYING PRODUCTION IN YOUR FISHPONDS

Introduction

You can intensify your production system by providing additional inputs to your pond and by increasing your management effort. By doing this you can increase the ponds carrying capacity, productivity, and output. There are several methods available to do this.

Options to intensify your production system:

1. Feed your fish (in addition to regularly fertilizing your pond)

- You can prepare and mix your own feeds using locally available materials. Refer to Section 3-3, "Feeding your fish."
- You can use feeds prepared for other animals, such as chick mash or pig starter pellets, if fish feeds are not available. Although these are not specifically formulated for fish, they can increase fish growth and will also supplement your use of organic fertilizers to enrich the pond.
- You can use commercial fish feed formulations when they become available.

2. Stock two or more species together in the same pond (polyculture)

- Stock catfish and tilapia together in the same pond. If you stock the right number of catfish, your tilapia production will remain the same or even increase, plus you will have the benefit of an additional species to take to the market.



Figure 4.7-1. Fish feeds such as brans (rice, wheat, corn) can be broadcast along the sides of ponds.



Figure 4.7-2. A home-made feed from a pellet machine.



Figure 4.7-3. Polyculture of Nile tilapia and African catfish can result in large, marketable fish of both species rather than just one or the other.

3. Stock your pond at a higher density than recommended for fertilized-only ponds. For example, you might increase your tilapia fingerling stocking rate from 1–2 fish/m² to 3–4 fish/m².

- Only do this if you have begun a feeding program and will be faithful in monitoring and managing your fishpond.
- Stocking at higher densities and adding feeding to your management scheme increases oxygen demand in the pond; you will therefore need to monitor it more closely for potential problems.
- Because of the increased oxygen demand of intensively managed ponds, mechanical aeration sometimes becomes necessary.
- Consult your local fisheries officer for advice on increasing your stocking densities.

4. Split your fish stock halfway through your production cycle

- You can stock your pond more heavily if partway through the production cycle you split the fish population into two groups. You can either move the fish to another pond on your farm or sell them to another farmer who will rear them to market size.
- Alternatively, you can simply move your entire population of stocked fish to a larger pond. The smaller pond then becomes available for restocking with another batch of fish.
- You must split your stock or move your fish to a larger pond if the carrying capacity of your pond has been reached but the intended harvest size has not yet been reached. Fish kept in the pond after its carrying capacity has been reached will not grow any larger, and keeping them in the pond will only cost you money.

5. Aerate your pond.

- With increased numbers of fish and the addition of feeds, your pond's oxygen demand will increase. In this case you may need to use mechanical aerators to compensate for the increased demand.

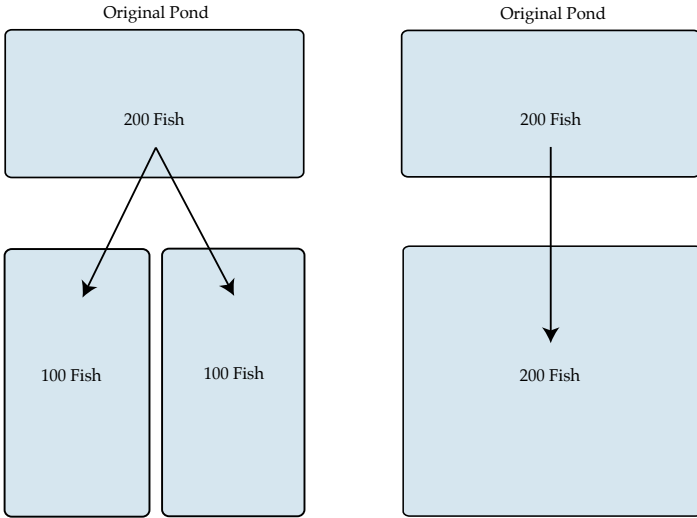


Figure 4.7-4. Splitting a stock of fish from one pond into two (left) or transferring a stock of fish to a larger pond (right) after carrying capacity has been reached.

- If power supplies are reliable in your area, you can use electric aerators to increase or maintain levels of dissolved oxygen sufficiently to support a greater mass of fish.



Figure 4.7-5. An electrical aerator.

Moving on

Take steps to intensify your production system only if you are willing and able to put in and sustain the extra effort required. Your pond will only produce more fish for you if you increase and maintain your management effort.

4.8: KEEPING FISH FARM RECORDS

Introduction

As a commercial fish farmer, your main objective is to earn money by selling fish at a profit. To understand why you are getting good or poor results, and—more importantly—whether or not you are making a profit, you will need to keep complete and accurate records of everything that goes on at your farm.

What are records?

Records are sets of information that have been systematically and carefully collected and appropriately stored for a specific purpose. To be able to run any economic enterprise successfully, carefully thought out and properly collected records are a must. Comprehensive record keeping will assist both in tracking farm activities and expenses and in assessing the level of investment, the motivation of the investor, and the management skills of the farmer. As the management level rises, culture systems become more complex and so does the record keeping. This is the reason the farmer must think very carefully about which records need to be kept.

Importance of record keeping

Maintaining good records helps you with the following:

- Tracking the activities of your enterprise
- Tracking the expenses of the enterprise
- Monitoring the performance of the enterprise
- Evaluating the performance and operations of the enterprise
- Making decisions about improving operations
- Keeping institutional memory of the enterprise

Good records will, for example:

- Be useful in projection of expected production
- Help in determining the amount of inputs required for specific ponds at various stages of fish production
- Help determine the expected harvesting time
- Determine the economic health of the enterprise

Important aquaculture parameters for record keeping

- Pond identity
- Total area under culture
- Fish species stocked
- Sources of seed
- Stocking densities and time
- Kinds, quantities, and costs of inputs
- Daily events
- Fish production in amounts and values
- Production of other farm crops and their values

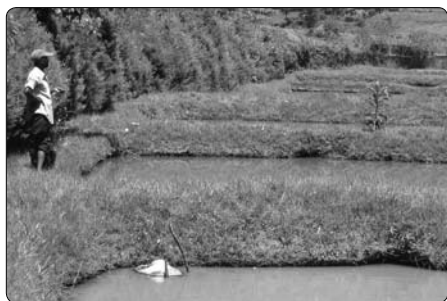


Figure 4.8-1. Monitor all ponds and other farm facilities on at least a daily basis to ensure that everything continues to function as it should.



Figure 4.8-2. Develop a system for keeping detailed records to ensure ponds are performing well and you are making money.

Classification of fish farming records

Fish farming records can be classified into:

- Fish farming biological management records, e.g.:
 - ◆ Specific pond production (quantity and value), by species
 - ◆ Stocking details for each pond (species and numbers)
 - ◆ Harvest details for each pond (species, numbers, and weights)
- Financial management records such as:
 - ◆ Purchase of inputs, including quantities and costs
 - ◆ Records of input usage, e.g., feeds and labour
 - ◆ Costs of labour, including the type and duration
 - ◆ Costs of new construction or repairs
 - ◆ Salaries, both in cash and in kind
 - ◆ Sales records, including what was sold, quantities, and prices
 - ◆ Inventory of equipment
 - ◆ Costs of renting or hiring equipment, machinery, services, etc.
- Records of significant events at the farm, including:
 - ◆ Visits by extension officers and recommendations given
 - ◆ Unusual weather that may affect pond productivity or farm operations

As the culture system becomes more and more complex and the management level intensifies, monitoring also becomes more difficult. This involves checks on:

- Water supply: Main water intake, main feeder canal, other canals, and pond inlets.
- Pond: Water level, water quality, dyke condition, bottom mud, aquatic vegetation, other structures.

- Fish: Behaviour, colour, feed utilization, growth/production, health.
- Farm: Protection (fencing, theft, erosion), stores/stocks, land vegetation, animal husbandry.

Reasons to monitor fish regularly:

- Check the general condition and health of the fish.
- Determine rates of growth.
- Determine efficiency of feeding (feed conversion).
- Adjust the daily feeding ration and save on feed costs.
- Check if stocking rate is appropriate; if too high, crop (out) the bigger fish.
- Check if stock is reaching target weights and help plan or revise the production or harvesting schedule.

As small-scale fish farming becomes a more commercial venture, maintaining detailed and accurate records becomes an important task to be carried out regularly by the farm manager for several reasons:

- Pond management records will be used for analyzing the production in each pond as well as for determining the reasons for good or poor results.
- Financial records of all transactions, both in kind and in cash, will keep the manager well informed on expenditures and incomes, hence help check how well the farm is doing as a commercial enterprise.
- Good records will provide a sound basis for future management practices and accurate planning and financing well an advance.

The types of records you should keep include:

- Quantities of inputs (lime, fertilizers, feed, etc.) used in each pond.
- Stores inventory and records of supplies added or removed.
- Costs of inputs (fingerlings, fertilizers, feeds, labor) for each pond.
- Stocking details for each pond (species numbers, and weights)
- Daily observations: notes about the weather, colour of water, visibility, dead fish, etc.
- Harvest details for each pond (species numbers, and weights)
- Fish production in each pond, total and by species.
- Income received for fish from each pond, by species and size group.
- Integrated production, for example chickens, ducks, pigs, sheep etc.
- Overall finances of the fish farm, i.e., expenditures and income.

Examples of record keeping forms:

Each farmer should develop a set of forms he or she can use for keeping farm and pond records. The following tables are examples of forms that might be used for record keeping:

Table 4.8-1, which is used for recording data on commercial fish stocks, has three major sections:

1. Stocking data (columns 1 through 6) includes date, species, number of fish, their total weight (kg), average weight (g). The origin of fish, their price, their condition, etc., may be noted under remarks. Total stocking weight (initial biomass) appears at the bottom of column 4.
2. Harvesting data (columns 7 through 11) includes date, species, number of fish, their total weight (kg) and average individual weight (g). From these the following parameters are calculated for the production section:
3. Production data:
 - Fish production (in kg, column 12) for each species and weight class. It is equal to output minus stocking weight, e.g. 368.9 kg of large sized fish of tilapia harvested from Pond B-1 on 30 Oct. Their production = $993.5 \text{ kg} - 122.5 \text{ kg} = 871 \text{ kg}$.
 - Duration of production cycle (in days, column 13).
 - Average production rate (in kg/100 m²/year, column 14) are estimated for each species and weight class as ((total production kg x 365)/(pond area in 100 m² x n days))
 - Average growth rate of fish (in g/day, column 15) are estimated as ((average weight at harvest – average weight at stocking)/n days) e.g., for tilapia it was $((122.7 \text{ g} - 20 \text{ g})/166 \text{ days}) = 0.62 \text{ g/day}$.
 - Survival rates (in percent, column 16) are obtained by comparing for each species, number of fish stocked (NS) to total number of fish harvested (NH), as $((\text{NH}/100) \times \text{NS})$
 - Under Remarks (column 17) note further information such as sale price of fish, destination after harvest, fish condition, etc.

Table 4.8-2 is used for recording data on periodic sampling of a fish crop: This form provides space for recording date, species, number in sample, total and average weights, days, total and average fish growth, estimated standing crop, survival (number and percent), and total biomass at the time of sampling (columns 18 through 30).

Table 4.8-3 contains sections for recording feed distribution, liming, and fertilization:

1. Feed distribution (columns 31 to 40) includes:
 - Period during which feeding rate was constant. Corresponds to period between two successive samplings of fish stocks for growth monitoring purposes
 - Duration of this period (in days)
 - Estimated biomass of fish present in the pond (kg)
 - Feed type – single feed items, e.g., maize bran (MB), wheat bran (WB), rice bran (RB), cotton seed cake (CSC), sunflower seed cake (SSC), or brewery waste (BW). It may also be a more elaborate mix of various ingredients.
 - Daily Feeding Rate (DFR, in percent of fish biomass per day).

- Feed ration to be used during the period (in kg/day). Multiply fish biomass (column 33) by DFR percent (column 35) (e.g., for the period from 20/6 - 3/7, feed $158 \text{ kg} \times 0.33 = 52 \text{ kg}$ of brewery waste per day).
 - Number of feeding days (column 37). As fish are usually not fed every day of the week, at the end of the period indicate how many days feed was distributed in the pond.
 - Total weight of feed distributed during the period (in kg, column 38) = daily ration (column 36) by number of feeding days (37).
 - Feed Conversion Ratio (FCR) or weight of feed distributed per kg of fish produced = total weight of feed given/fish production during the period (e.g., for the period 5/7 - 20/7, $\text{FCR} = 372 \text{ kg}/64 \text{ kg} = 5.8$. At the bottom of the form, obtain the overall FCR for the production cycle in a similar way, after adding up columns 37 and 38.)
 - Under the remarks (column 40) add any information useful to the interpretation of the results such as feed quality, type of mix, feed cost, fish behaviour, water quality, etc.
2. Liming and fertilization (columns 41 through 44) includes:
- Date on which fertilizer is applied to the pond (41).
 - Fertilization, type and total amount applied (in kg) (42).
 - Under remarks note further information such as method of application, quality of fertilizer, price, etc. (42 - 43).
 - If you are liming a pond, either before filling or later, record the information either in one additional column or in column 43.
 - Any remarks are put in column 44.

And finally, a form for keeping track of activities in each individual pond is very useful. This example of a **Pond Record Form** includes space for the following kinds of information:

- Stocking records
- Harvesting records
- Pond Management Records: Inputs (Feeds and/ or Fertilizers)
- Visits by extension agents
- General remarks

Moving on

Keeping good records of farm operations contributes directly to understanding the economics — particularly the balance between costs and returns — of your operation, which determines how profitable it is. The next section describes two major economic tools you can use to help monitor and evaluate your enterprise.

Table 4.8-1. Fish stocking, harvesting, and production. Pond B-1 .Size: 1,321 m². Type of production: Food fish.

STOCKING				HARVESTING				PRODUCTION								
Date	Species	No.	Weight (kg)	Remarks	Date	Species	Yield	Total	Days	Production Kg/100 m ² /yr	Average growth (g/d)	Survival	Remarks			
			Avg. (g)				No. (kg)	(g)								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1/3	TN	6125	122.5	20	Pond 9	30/10	TN	3154	993.5	315	871	243	1.7	-	51.5	Partial crop-sale @ Kshs 70/kg
20/7	CG	234	27.3	117	Pond 8	14/11	TN	3007	246.4	122.7	246.4	166	17.4	0.62		Final crop-sale @ KShs 70/kg
						-	CG	224	158.7	830.0	158.7	117	15.9	6.09	96.9	Sale @ KShs 50/kg
						-	TN	834	25.2	30.1	25.2	-	-	-		Fingerling to pond 4
Total			149.8			Total			601.5		451.7	(166)	31.8	-		

TN = Nile tilapia (*Oreochromis niloticus*); CG = African catfish (*Clarias gariepinus*)

Table 4.8-2. Periodic fish sampling.

Date	Sp.	No. sample	Weight		Days	Fish growth		Surv. (%)	Est. standing crop		Production (kg)	Remarks
			Total-kg	Avg-g		Total-g	Avg-g/d		Total No.	Biomass-kg		
18	19	20	21	22	23	24	25	26	27	28	29	30
1/6	TN	-	-	20.0	0	-	-	-	6125	122.5	-	1 st stocking (tilapia)
20/6	TN	164	4705	28.7	19	8.7	0.46	90	5512	158	35.5	1 st sampling by seining
5/7	TN	145	7150	39.7	15	11	0.73	95	5236	208	50	Reproduction has started
20/7	TN	172	11000	54.7	15	15	1.00	95	4974	272	64	Cast net plus seining
-	TN	29	0.133	4.6	-	-	-	-	-	-	-	1 st fry in sample
20/7	CG	-	-	-	0	-	-	-	234	27.3	-	Second stocking (catfish)
3/8	TN	126	9575	66.7	14	12	0.866	90	4476	298	26	2 cormorants seen feeding
-	TN	43	0.267	6.2	-	-	-	-	-	-	-	
18/8	CG	11	1925	175.0	15	58	3.87	98	229	40	12.7	

Table 4.8-3. Feed distribution and liming/ fertilization in a 3,121 m² pond.

Feeding Period		FEED DISTRIBUTION										LIMING AND FERTILIZATION			
From-to	Days	Biomass (kg)	Feed type	DFR %/ day	Ration Kg/ day	Feed days	Total feed kg	FCR	Remarks	Date	Organic (kg)	Inorganic (kg)	Remarks		
31	32	33	34	35	36	37	38	39	40	41	42	43	44		
1/6-20/6	19	122.5	BW	33	40	14	560	15.8	Fresh BW; transport cost only				Horse manure		
20/6-5/7	15	158	BW	33	52	10	520	10.4					Avg dose 30g/m ²		
5/7-20/7	15	208	RC+ CC	15	31	12	372	5.8	Mix 2:1 (rice bran : cotton seed cake)				Chicken manure		
20/7-3/8	14	338	BW	20	67	9	603	15.6	BW slightly fermenting, low DO				Manure diluted & distributed		
Total	166	-	-	-	-	143	6008	13.3		Total	3937	SP 97			

CHAPTER 5: HATCHERY MANAGEMENT

For farmers who have the needed resources and who have gained sufficient experience and skill taking care of fish, producing fingerlings for stocking or for sale is another aspect of fish farming that may be of interest. Most fish farmers in Kenya are probably aware that the supply of fingerlings is often insufficient to meet the demand, which means that a farmer who can efficiently produce fingerlings should be able to make a profit by selling them. Specializing in fingerling production involves activities such as maintaining a stock of adult fish (broodfish) for spawning, establishing and preparing spawning areas (ponds, tanks, or hapas), inducing the fish to spawn, incubating eggs, and rearing the young fish (fry) until they are large enough and strong enough to survive in an open pond. This usually requires some additional space and equipment, which may collectively be referred to as a "hatchery." Successful production of fingerlings, whether of tilapia or catfish, will require the use of good hatchery management practices, as outlined in the next two sections.

5.1: GENERAL HATCHERY CONSIDERATIONS

Introduction

Hatcheries are used to produce fry or fingerlings for stocking fish ponds. A hatchery can also be used as a breeding centre for genetic improvement of fish stock. Many catfish and tilapia farmers who are engaged in food fish production find that an adequate supply of fingerlings is not always available. As long as the demand for fingerlings exists, a well-managed hatchery can be a lucrative business. Farmers are therefore encouraged to set up their own hatcheries to produce fingerlings either for themselves or for sale. As the industry expands, the importance of having a reliable supply of high-quality fingerlings will become more apparent.

Hatchery design

When designing the hatchery, the most important consideration is the water supply, including both its quantity and its quality.

- The hatchery design should incorporate a good filtration system to improve water quality, reduce any pollution, and prevent the entry of predators such as insect larvae.
- Farmers are advised to site their hatcheries on a slope so that water can flow into the hatchery by gravity. Sites should therefore have good soil characteristics and a suitable land gradient.
- All incoming water should be filtered. Alternatively, only ground water should be used where possible.
- Where possible, tanks, incubators, troughs, and other receptacles should be movable to allow for future modification.
- If earthen ponds are to be constructed as part of the hatchery, then sandy or gravelly soils should be avoided. An impervious soil (i.e., one with a sufficient clay content) will hold water and prevent seepage.
- Land that is gently sloped provides drainage and allows the construction of raceways in a series for reuse of water by gravity flow.

Hatchery equipment

- Containers for rearing the fish are the major item needed. Examples include small buckets, long trays or troughs, aquaria, and large circular or oval tanks. You can use containers made from plastic, glass, or wooden materials.
- Other items include weighing scale, netting materials, ruler, towels, trays, syringes and needles, sharp knife, mortar, pair of scissors, salt solution, thermometers, glassware or plastic basins (various sizes), and brushes.

Rearing facilities

- Rearing units include small tanks or troughs for swim-up fry, intermediate-size rearing tanks for fingerlings, and large outdoor rearing ponds or raceways.

- Rearing units should be constructed so they can be drained quickly and independently.
- Rearing units should be adequate not only for the normal everyday water flow in the hatchery, but also for increased volumes of water needed during draining and cleaning of the facilities.

Broodstock selection and maintenance

- Select quality broodstock to improve fish production on your farm.
- Choose pure quality stocks and do not allow them to crossbreed with other strains to preserve their genetic quality.
- Teach your workers the importance of preventing genetic contamination.
- Initially you may have to collect your broodstock from the wild, whereas later you can select them from your own ponds or purchase them from other farmers.
- If buying your fish stocks from others, buy them only from reliable and established sources and avoid introducing breeders from non-accredited sources.
- Use brood fish that are mature but not too old; for catfish and tilapia they should be at least one year old but not more than three years old (> 100 g for tilapia and between 0.5 and 1.0 kg for catfish).
- By using larger brood fish, you can easily identify the original stock after each production cycle.
- You can use the same stock repeatedly, depending on their performance, but should adopt a culling/selection process to eliminate undesirable stock.
- Always eliminate fish that have questionable characteristics by examining breeders carefully when re-stocking after each cycle.

Moving on

With these general considerations in mind, you are now ready to look at seed production practices for tilapia and catfish, which will be covered in the next two sections.

5.2: TILAPIA SEED PRODUCTION

Introduction

Although tilapia breed frequently in unmanaged ponds, the small number of fry they produce means that fish farms need to invest in systems for fry and fingerling production. The systems used are ponds, net enclosures (hapas), and tanks. Breeding systems depend on the natural behavior of the fish. Three methods of tilapia seed production are commonly practiced. For all methods, fry collected from the spawning unit are usually stocked into fertilized ponds for rearing to the fingerling stage.

The open pond method

The open pond method is the simplest and most common method of tilapia fingerling production. In this method, a pond serves both for spawning and rearing. Breeders are stocked into the ponds and allowed to spawn naturally.

Follow these guidelines to use the open pond method:

- Stock your broodfish at the rate of 100 to 200 kg brood stock per hectare.
- Stock a sex ratio of 1:3 or 1:4 (males to females).
- A female brood fish of 90-300 g produces as much as 500 eggs per spawning. They should produce 6-15 fry/m²/month or 35-100 fry/female/month.
- Harvest fry from the pond every 15-21 days. The frequency should be increased if average temperatures are above 25°C.
- You can continue to use your brood fish continuously for a period of 3-5 years.
- You can increase seed production to 45 fry/m²/month or 380 fry/female/month by using larger broodstock (1-1.5 kg) and harvesting fry every 17-19 days.
- It is also useful to collect the fry with hand nets from along the edges of the pond on a daily basis to avoid disturbance of spawners and damage to fry.

The "hapa" method

A hapa is a rectangular or square net enclosure used to hold fish for various purposes. Hapas are usually made of fine nylon, plastic mosquito netting, or cotton mesh. Hapas are very easy to manage because fry cannot escape and harvesting is much easier. A hapa measuring 3 m long, 3 m wide, and 1.5 m deep is the most common size used. Hapas are usually installed in ponds, lakes, or along river banks with slow moving current.

1. Guidelines for using hapas

- Stock broodfish at a ratio of about 1:5 to 1:7 (males to females).
- Use brooders that weigh about 100 to 200 g each.
- Brooders are usually stocked at the rate of 4-5 brooders /m².
- Check the hapa daily for the presence of schooling fry. Two weeks

after stocking of breeders, use a fine-mesh dipnet to scoop out fry and transfer them to tanks, other hapas, or a rearing pond.

- Production rates range from 150 fry/m²/month or 50 fry/female/month to over 880 fry/m²/month or 300-400 fry/female/month.

2. Feeding

- You must feed fry reared in a hapa on a daily basis.
- Feed fry a diet in powdered form at the rate of 5-10 percent of the total body weight per day.
- Divide the daily feed ration into four feedings per day until the fry reach the desired size (5 g).

3. Advantages of the hapa method

- Production on a per square metre basis is high.
- Fry are more uniform in size.
- Fry and broodfish are easily handled.
- Maximum recovery of fry is possible.
- Hapas may be set up in many different areas of the pond.

4. Disadvantages of the hapa method

- Management is more complicated and intense compared with the other methods.
- Aggressive males may kill females during spawning.
- Broodfish held in hapas are easy targets for poachers.
- Hapas may be destroyed or blown away during stormy weather.
- Feeding of broodfish and fry is a must.
- Netting material may degrade in sunlight and need replacing annually.
- Fish may easily escape if the netting is torn.
- Small organisms and uneaten food in the water may clog the mesh. This limits water circulation in the hapa and may reduce oxygen concentrations to critical levels.
- The net may require periodic scrubbing to remove undesirable organisms from the mesh.

The tank method

Tank-based hatcheries are easily managed but are relatively expensive to build. The following guidelines apply to the tank method:

- Use circular tanks of 1-6 m diameter containing 0.5-0.7 m of water.
- Stock 100-200 g broodfish at 3-5 per m² at a sex ratio of 1 male to 2-7 females.
- Feed using a 30-40% crude protein diet at a rate of 1-2% body weight/day.
- Collect eggs every 5 days or collect eggs and fry every 10-14 days; seed yields of up to 400-3,000 fry/m²/month or 200-1,500 fry/female/month can be achieved by this method.

An advantage of using the tank method is that tanks are very easy to manage. On the other hand, tanks are often relatively expensive to purchase or build.

Production of all-male fingerlings

Regardless of which of the above methods is used to produce tilapia fry, some farmers may want to produce all-male populations of tilapia fingerlings for stocking into ponds. All-male populations can be obtained by at least two practical methods, hand sexing and hormonal sex reversal. Each method has advantages and disadvantages.

Hand Sexing

- Sexual features distinguishing males from females are clear when fish mature, which occurs at about 10 cm in Nile tilapia.
- Males have two orifices situated near the ventral (anal) fin. One is the urogenital opening and the other is the anus. Females have three orifices, the genital opening, the anus, and a urinary orifice which is difficult to see with the naked eye.
- Hand sexing requires extensive nursery facilities for rearing the fry to produce advanced fingerlings for sexing at around 20 g. It is a relatively inefficient means of producing an all male population, however.
- Separation of males and females can be made easier by applying dye (India ink, halcyon blue, or indigo) to the papilla with a soft brush or cotton swab to outline the male and female openings. Skilled hatchery workers can achieve over 95 % male populations on 5 to 7 cm fish.
- Manual sexing should be done early in the morning so fish will not be stressed by high water temperatures.
- Culled females may be used as brood stock, eaten, sold, fed to livestock, or preserved by drying, salting, or smoking.

Hormonal sex reversal

- A tank-based or hapa-based (small cage net) hatchery is needed so that fry can be collected at the yolk sac or first feeding stages, no later than one week after they have been released from the female.
- Healthy fry of uniform size are transferred to the tank or hapa, where they are fed the hormone-containing diet for a period of 21-28 days.
- The method for preparing sex reversal feed is as follows:
- Mix 30-70 mg of hormone (methyl or ethynyl testosterone) in 700 ml of 95% ethanol.
- Add 700 ml of hormone solution to each kg of finely ground feed.
- Mix thoroughly and dry.
- Add any supplements.
- Refrigerate (if the feed is not to be used immediately).
- Feed at a rate of 10-30% of body weight per day, at least four times a day, for 21-28 days.
- The fry must eat the feed containing the sex reversal hormone and no natural food.

Moving on

This section has considered seed production techniques for tilapia. The next section addresses seed production techniques for the African catfish.

5.3: CATFISH SEED PRODUCTION

Introduction

Under pond conditions catfish mature after 7-10 months and weigh about 200 to 500 g. Spawning does not normally occur in managed ponds because the final stimulus associated with a rise in water level and inundation of marginal areas does not occur. However, catfish can be induced to spawn by hormonal treatment using pituitary glands from donor fish. Catfish raised from egg to maturity in a hatchery remain mature all year round and regression of the gonads does not occur. This suggests that adequate supplies of fry should be obtainable throughout the year.

Broodfish maintenance

- Maintain a conditioning/fattening pond of about 100-200 m² for your broodfish. This size of pond will hold 300 brooders (150 males and 150 females). The pond should be sufficiently deep—about 1.0 to 1.50 m.
- Prior to filling and stocking the pond, fertilize it with organic or inorganic fertilizers to maintain its natural food production. Also apply lime in areas where the pond waters are acidic (see Section 4.1 in this guide).
- Stock the conditioning pond at a density of 2-5 brooders per m².
- Feed your broodfish with a 40% crude protein feed three times a day at 1% of their body weight. Whenever possible it is advisable to stock small tilapia with the brooders to serve as supplemental food.
- Stop feeding the broodfish one day prior to collecting them for spawning.

Spawning

1. Selection and handling of brooders

- Capture and transport fish early in the morning or late in the evening when it is cool. Ice can be used to reduce sudden changes in water temperature. Anesthetics have also been used to reduce fish stress during transportation and transfer to tanks.
- Handle your broodfish as little and as gently as possible to avoid stress. Damage to the slime (mucus) layer can lead to infection.
- Use a seine to gently capture enough fish to be able to select sufficient males and females for spawning.
- After collection of the fish from the conditioning pond, disinfect them in a formalin bath to prevent the transfer of pathogens from fish to eggs and fry.
- Selection involves separating males from females and checking for maturity. Do this by gently pressing the abdomen with the thumb; fecund females release shiny greenish eggs. Mature males cannot be stripped and can only be selected by their size.
- Choose females of about 0.5 to 1.0 kg; this size has a substantial

quantity of eggs and is easier to handle than larger fish.

- For each female use at least two males of the same total weight.

2. Collecting and injecting the pituitary

- To avoid temperature shock it is advisable to use a thermostat or heater where available.
- Brooders should be held without food for 24-36 hours in a container at 25- 30°C prior to injection with pituitary.
- Pituitary can be collected from either male or female fish.
- For each female spawner, two pituitary donors of 500 g average weight are used.

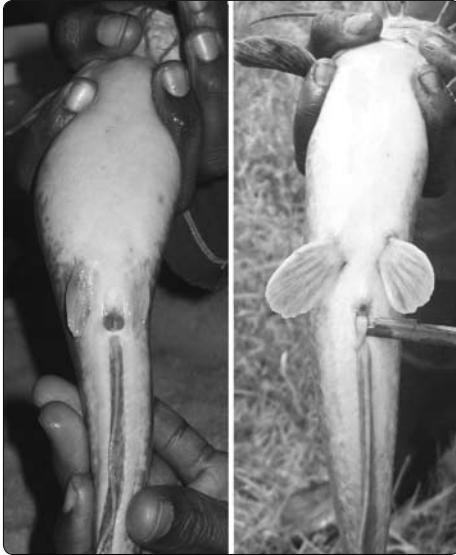


Figure 5.3-1. Adult male and female African catfish (*Clarias gariepinus*) can be distinguished by features in the urogenital area. Note that the genital papilla of the male (right) is much more pronounced than that of the female (left).

- When using fresh pituitary, kill and decapitate donors less than an hour before planned injection. Open the palate of the mouth with a pair of pincers and locate the pituitary just below the ventral side of the brain.
- Collect pituitary from the donor and place it in a mortar containing 2 ml physiological salt solution (9 g salt in 1 litre water).
- Grind the pituitary, mixing it well with the saline solution.
- Alternatively, pituitary can be stored for months in 1 ml acetone in a cool dry place to be used later.
- Using a syringe with a needle 2.5 to 3.0 cm long and a diameter of 0.7 mm, draw the pituitary suspension and prepare to inject the fish.
- Cover the head with a hand towel and insert the needle at an angle of 45 degrees in the dorsal muscle. Inject and finger-rub the intramuscular area to distribute the suspension evenly.
- Place the fish back in the container and wait for about 12 hours

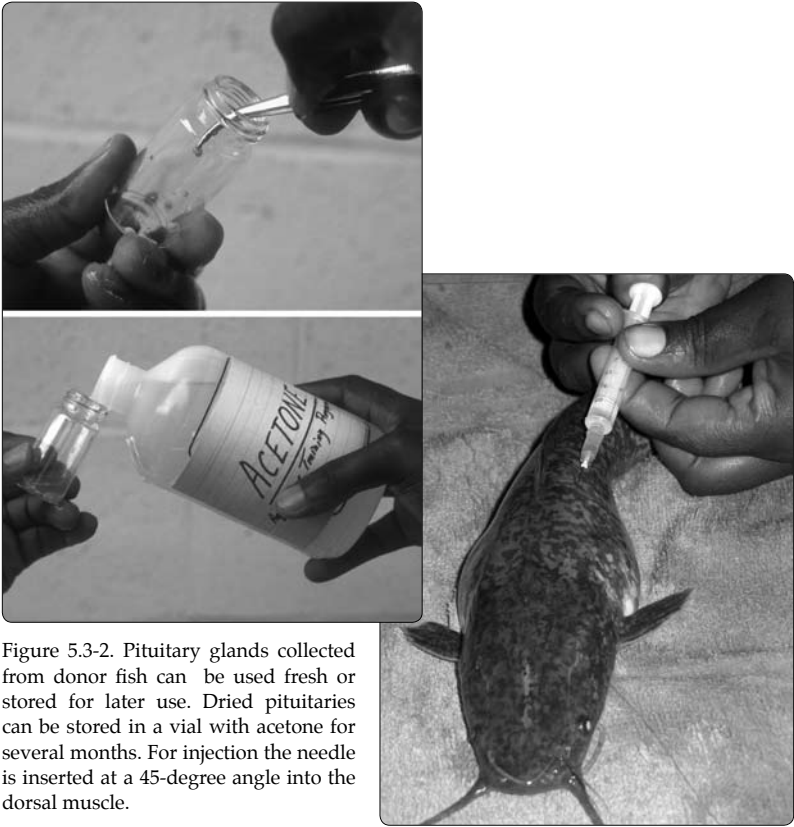


Figure 5.3-2. Pituitary glands collected from donor fish can be used fresh or stored for later use. Dried pituitaries can be stored in a vial with acetone for several months. For injection the needle is inserted at a 45-degree angle into the dorsal muscle.

until all eggs have matured (see Table 5.3-1).

- During ovulation, the belly of the female will swell due to water absorption of the ovary. If the female has responded well, eggs will easily run out from the genital papilla when the belly is gently pressed.

3. Stripping the female and fertilizing the eggs

- Gently strip eggs from the female into a dry bowl and estimate the number of eggs (One gram contains about 600-700 eggs).
- Male gonads can be removed and macerated (mashed) and the milt mixed with eggs at the time of stripping the female.
- Squeeze the freshly dissected testes and distribute the milt droplets evenly.
- Immediately add some clean water to the bowl and mix eggs with the sperm by gentle swirling of the bowl.
- Use a feather to mix the eggs and milt.

Table 5.3-1. Time interval (Hrs) between injection and stripping (latency time) of the female fish and incubation time in relation to water temperature.

Water Temp (°C)	Latency Time (h)	Incubation Time (h)
20	21	57
21	18	46
22	15.5	38
23	13.5	33
24	12	29
25	11	27
26	10	25
27	9.0	23
28	8.0	22
29	7.5	21
30	7.0	20

Incubating the eggs

- Pour the fertilized eggs into an incubating tray in a single layer. Within a few minutes after fertilization, the eggs will absorb water and sticky attachment discs will develop.
- Incubate the eggs in flowing water with a flow-through rate of 1-3 litres per minute.
- Healthy developing eggs have a transparent greenish-brown colour whereas dead eggs are white; dead eggs must be removed immediately to avoid fungal infection.
- Depending on ambient water temperature, eggs will take 20-57 hours to hatch (Table 5.3-1).
- Where a screen is used to incubate eggs, hatchlings will fall to the bottom upon hatching. They can also be siphoned out into a tank where they will rest as they absorb their yolk.
- Hatchlings must be separated from the egg shells to avoid infections that can lead to mortality. At this stage of development, the hatching rate will be about 50-80%.
- Hatched fry are 5-7 mm in length and weigh about 1.2-3.0 mg. They look like tiny needles with a green globe, the yolk-sac.
- Due to the weight of the yolk-sac, hatchlings will fall to the bottom of the container. They will cluster together in dark places in the tank and will require a cover and aeration.
- Within 3 days the yolk sac will be absorbed and the swim-up fry will start to search for food. With good management, 90-95% of the larvae will survive and develop into fry.
- Transfer fry in buckets to weaning tanks or nursery ponds (weaning tanks preferred).

Larval rearing

Several factors are of great importance when nursing catfish larvae:

- Start them out in a protected hatchery environment (rather than stocking them directly into ponds) to increase survival rates.
- Stock them at an appropriate density (about 100 larvae per litre) to get better growth and survival.
- Availing large quantities of zooplankton (for example, rotifers or *Artemia*) as starter feeds for the first 10-14 days helps increase growth and survival rates.
- Transfer the fry to hapas (feed well with live and artificial feeds) or to a well-prepared (zooplankton-rich) nursery pond to increase survival.



Figure 5.3-3. Aquaria can be used to rear catfish larvae in the hatchery.



Figure 5.3-4. Hapas can be placed in ponds to protect catfish fry during the early pond-rearing period.

1. Hatchery rearing

- After removal of dead eggs from the incubation trays or screens, transfer the live yolk-sac larvae to tanks or aquaria in the hatchery for further rearing.
- Rear the young fish in the hatchery for 7 to 14 days (depending on water temperature) to achieve optimal survival when they are later transferred to nursery ponds.
- Stock the larvae at a density of about 100 larvae per litre of water.
- Maintain the water temperature at about 28°C.
- Feed the larvae as much as they will eat in 15 minutes every two hours (around the clock) during the hatchery phase (about 14 days).
- With this management you can expect a highly acceptable growth rate and a survival rate of 80% or better at a low cost.

2. First feeding of catfish larvae

- Catfish larvae normally begin feeding on the second or third day after hatching, before the yolk sac is completely absorbed; therefore you must begin to feed them at this same time when rearing them in the hatchery.
- When they begin feeding, the larvae normally utilize live feeds and their systems are not sufficiently developed to utilize dry (manufactured) feeds; it is therefore recommended that dry feeds be supplemented with *Artemia* nauplii or rotifers during at least 3 of the 10 to 12 daily feedings for the first three to four days of feeding.
- If an abundance of live food is available, maintain a constant concentration of live food organisms in the larval rearing system, as this greatly enhances their growth rate.
- It has been shown that a continual supply of food produces the highest growth rates; you should therefore feed your larvae as much as they will consume in about 15 minutes by hand every 2 or 3 hours for 16 to 18 hours each day.
- Feeding with live feeds such as *Artemia* nauplii or rotifers has advantages over dry feed; for example, the best growth is obtained when larvae are fed *Artemia* only (250 mg average weight after 11 days).
- Feeding with *Artemia* nauplii or rotifers is stopped on the second or third day after the start of exogenous feeding, when the larvae are big enough to ingest inert food particles or zooplankton (usually *Daphnia*).
- The larvae grow very rapidly after the start of feeding (about 100% body weight/day).

3. Predation on the larvae

- One of the most serious predators in ponds is toad tadpoles. The presence of tadpoles is also a nuisance because they compete for food resources within the pond.
- Other predators include backswimmers, insect larvae, copepods, etc.
- It has been observed that predation pressure can be very high (100% mortality) during the yolk-sac stage but decreases gradually as the larvae increase in size.
- It is therefore suggested that fry be transferred to nursing ponds only after they have reached a size greater than 10 mm to avoid losses to predation during the primary nursing phase.

4. Transferring catfish fry to nursery ponds

- After approximately 14 days in hatchery tanks, the fry can be transferred to ponds.
- Ponds should be well prepared to receive the fry. This includes proper pond bottom drying between crops, liming when needed, and proper fertilization to develop abundant supplies of natural foods for the fry to be stocked.
- Where possible, use hapas in ponds to further protect your fry and

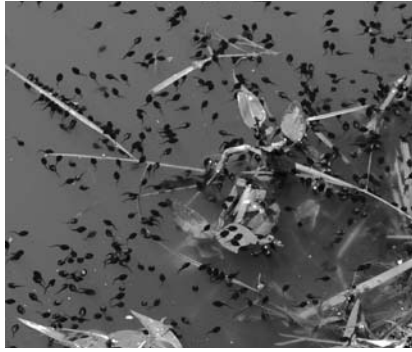


Figure 5.3-5. Tadpoles can be one of the most serious predators for catfish larvae stocked in open ponds.

increase their growth and survival rates. For best results, totally cover the tops of the hapas with cut grasses or other materials to provide the maximum possible amount of shade for the fry.

- After 14 days in the hatchery, fry transferred to hapas or nursery ponds should be reared an additional 14 days, or until they reach a length of 2-3 cm. This is a suitable size either for stocking into production ponds or for use as baitfish.

Factors contributing to the growth and survival of catfish fry

Factors that influence the growth and survival of catfish fry include:

- Stocking density: High stocking densities result in poor growth and survival; low stocking densities enhance growth and survival, but are less economical.
- Cover or shading: Cover and shading enhance growth and survival, whereas exposure to light lowers growth rates and increases mortality by contributing to increased cannibalism and stress.
- Production period: Most mortalities occur during the early part of the nursing phase. The first 30-45 days is critical; thereafter survival is often close to 100%.
- Cannibalism: Losses due to cannibalism can be minimized by providing cover (shade) and adequate amounts of high quality feed.
- Predation: Predation by tadpoles significantly reduces survival.
- Feeding: The availability of live feeds greatly reduces mortality.

Moving on

This section concludes this manual's consideration of technical aspects of fish farming such as site selection, pond design and construction, and pond and hatchery management. In the next chapter we will consider the basic economic aspects of fish farming, focusing on tools such as enterprise budgets and cash flow analyses, which can assist the farmer in evaluating a fish farming enterprise, whether it is one already in operation or is a potential system still under consideration.

CHAPTER 6: FISH FARMING ECONOMICS

Definition of economics

Economics is the study of the production and distribution of economic goods and services, bearing in mind that the necessary resources (land, water, money, inputs, etc.) are always limited. Farmers therefore have to make choices on how best to utilize the resources that are available to them for maximum benefit.

Opportunity cost

Opportunity cost is the next best opportunity one foregoes as a result of selecting one out of several possibilities. For example, if a farmer decides to invest in fish farming, that decision implies a loss of the benefits that would have resulted from investing in poultry farming, crop farming, cattle-rearing, or another farming enterprise.

Farm management

In a commercial setup, the fish farmer has to understand that fish are usually reared for economic benefit. The farm manager has to make many organizational and operational decisions; key among these are:

- What species of fish to produce?
- What quantity of the selected species to produce?
- What mix of resources and technology to use?
- When and where to sell or buy?
- How to finance the operation?

Objectives of a private enterprise

Fish farmers should expect economic gain through providing food for the family, selling fish crops, or offering services such as sport-fishing in exchange for monetary gains. This should be every farmer's goal.

Examples of aquaculture enterprises

Some possible aquaculture enterprises include the following:

- Culture of Nile tilapia (*Oreochromis niloticus*)
- Culture of African catfish (*Clarias gariepinus*)
- Polyculture of tilapia and African catfish
- Culture of trout (*Onchorynchus mykiss*)
- Culture of ornamental fish in fresh and sea water, e.g., goldfish
- Culture of marine shrimp, crayfish, or freshwater shrimp
- Culture of oysters
- Culture of the spiny lobster
- Providing support services for aquaculture (harvesting, water treatment)
- Processing farmed fish for sale
- Manufacturing fish feed
- Consulting and training for the aquaculture industry

Types of fish products derived from aquaculture

- Fingerlings, fry, and live eggs
- Live or fresh food-fish (tilapia, catfish, trout, and crustaceans)
- Live ornamental fishes
- Processed fish: smoked, filleted, de-headed, sun-dried
- Eggs

6.1: ENTERPRISE BUDGETS

Introduction

An enterprise budget is a tool you can use to estimate all expected costs and income for your enterprise over a specified period of time, e.g., your fish production operation during one growing season or one year. Preparing an enterprise budget helps you predict whether or not the fish farming enterprise will be profitable.

If we assume that a farmer has made all the capital investments required to start the enterprise, normal operating costs incurred and revenues received per unit time (e.g., one year) can be summarized into an enterprise budget.

To develop an enterprise budget, the following types of assumptions must be made:

- Establish the source of operating funds: Are they from loans or from savings?
- There is a ready market for the fish
- The investor is not salaried; she/he relies solely on farm profits
- Establish the interval of harvest (growing period) and expected yield
- Estimated mortality or survival rate for the fish stock
- Prevailing bank interest rate

Components of an enterprise budget

Gross Receipts

The first step in developing an enterprise budget is to estimate the total fish production and expected output price. The total value of the fish sold is called the Gross Receipts.

Variable Costs

The second step is to estimate the variable costs. Variable Costs are the cash expenses directly related to production. These costs vary with the scale of production or farm size.

Fixed Costs

Fixed Costs are incurred regardless of whether or not production occurs. Certain items that outlive one production period must be purchased. Only expenses related to land and equipment should be considered (land lease, annual depreciation of machinery, interest rates) because it is assumed that ponds are already constructed. Salaries for permanent staff may also be considered.

Total Costs

This is the sum of Variable and Fixed Costs.

Net Returns

This is the difference between Gross Receipts and Total Costs.

Break-even Analysis

A “break-even price” can be calculated and used to gauge whether your operational costs are covered by your income. The break-even price is the price at which expenses per kg and income per kg are just equal. It is expressed in KShs per unit weight (kg).

Break-even Price

This can be calculated to cover:

a) Variable expenses:

Total variable expenses (KShs)/total fish produced (kg)

b) Total expenses:

Total expenses (KShs)/total fish produced (kg)

Break-even Yield

a) Break even yield (BEY) above total cost (TC) is defined as production where total gross receipts are equal to total costs. This is calculated as follows:

BEY above TC = Total costs/price per unit

b) Break even yield (BEY) above total variable cost (TVC) is defined as production where total gross receipts are equal to total variable costs. This is calculated as follows:

BEY above TVC = Total variable costs/price per unit

Income per Unit Area

Some people may want to find out how much they are earning per unit area of pond water. To calculate earnings per unit area:

Income = Net Income (KShs)/Total area of pond (ha)

A Sample Enterprise Budget

An example of an enterprise budget is shown on the following page.

Moving on

As we have seen, an enterprise budget helps a farmer evaluate the farming operation by estimating all costs and expenses over a particular period of time. In the next section we will see how cash flow analyses help visualize the month-to-month inflow and outflow of cash, making it easier for a farmer to plan for periods of low income and/or high expenses.

Table 6.1-1. An example of an enterprise budget for a five-hectare production farm.

Variable costs	Unit	Price			Value	
		(KSh)	(\$US)	Quantity	(KSh)	(\$US)
<i>First phase: no feed</i>						
Urea	kg	19	\$0.27	2700	51,300	\$733
D.A.P.	kg	23	\$0.33	2000	46,000	\$657
T.S.P. to satisfy soil phosphorus demand	kg	25	\$0.36	3125	78,125	\$1,116
Tilapia fingerlings	piece	3	\$0.04	112500	337,500	\$4,821
<i>Clarias</i> fingerlings	piece	5	\$0.07	12500	62,500	\$893
Field labor: stock, feed, fertilize, harvest	man-day	120	\$1.71	400	48,000	\$686
Security personnel	night	150	\$2.14	416	62,400	\$891
<i>Second phase: bran plus fertilizer</i>						
Bran cost including transport	kg	3	\$0.04	75000	225,000	\$3,214
Urea	kg	19	\$0.27	3896	74,017	\$1,057
D.A.P.	kg	25	\$0.36	5915	147,875	\$2,113
Field labor: stock, feed, fertilize, harvest	man-day	120	\$1.71	525	63,000	\$900
Labor, levee renovations, after draining	man-day	120	\$1.71	375	45,000	\$643
Security personnel	night	150	\$2.14	416	62,400	\$891
Sub total variable costs					1,303,117	\$18,616
Interest on operating capital: 16% p.a.					208,499	\$2,979
TOTAL VARIABLE COSTS					1,511,616	\$21,595
<i>Fixed costs</i>						
Amortization of ponds, equipment, 15 yrs	ponds	2000000	\$28,571	0.067	133,333	\$1,914
Interest on investment, ponds only	16% p.a.	2000000	28,571	0.16	320,000	\$4,571
TOTAL FIXED COSTS FOR 1 YEAR					453,333	\$6,486
<i>Gross receipts</i>						
Tilapia sold	kg	100	\$1.43	30453	3,045,313	\$43,504
<i>Clarias</i> sold	kg	100	\$1.43	4693	469,281	\$6,704
TOTAL REVENUE					3,514,594	\$50,209
RETURNS TO LAND, WATER AND MANAGEMENT:					1,549,645	\$22,128
Breakeven price per kg fish					55.9	\$0.80
Breakeven yield (above total costs)	kg			19,662		
Breakeven yield (above total variable costs)	kg			15,101		

Assumptions:

- Fingerlings are purchased off-station.
- Price for tilapia and catfish is KShs 100/kg
- Fingerlings are stocked at an average weight of 15 g and a density of 25,000 per hectare
- First phase is 140 days; second phase is 200 days.
- Exchange rate: KShs 70 to 1 USD (Jan. 2007 rate)

6.2: CASH FLOW ANALYSIS

Introduction

Apart from the enterprise budget, it is important for a farmer or a funding agency to gauge the day-to-day revenues and expenses incurred by a farm so as to determine its viability. Cash flow analysis deals with how cash is utilized by the production systems within a farm setting. Cash should always be available to purchase farm inputs, pay for labour and other costs, or long-term financial commitments during the course of production, whether it be obtained from farm sales, savings, or bank loans (short-term).

If the cash flow analysis indicates that cash inflow is greater than cash outflow, there are no cash flow problems but this does not indicate profitability. However, if expenses are greater than income, then the farm business will have cash flow problems. In fish farming, expenses are incurred every day, whereas revenues may be received only after harvests. This means that careful utilization of the operation's funds is critical.

Components of cash flow analyses

There are three main components in a cash flow analysis: cash inflow, cash outflow, and summaries and balances.

Cash Inflow

This includes all sources of revenue received by the fish farming enterprise.

Cash Outflow

This includes all cash utilized for variable and fixed expenses (farm input purchases, salaries, etc.).

Financial Section Summaries and Balances

Net cash balance for each month is the difference between cash inflow and total cash outflow for that month. This amount is brought forward to be the beginning cash at the start of the next month and so on throughout the year. If expenses (cash outflow) are greater than income (cash inflow) for any given month, the net cash for that month will be a negative value.

An example of a Cash Flow Analysis is shown in Table 5.2-1. The example is for a tilapia farm having two fishponds and using a semi-intensive management production strategy. Fish are stocked in January and the harvest does not take place until October, although the farmer starts selling fingerlings in March. The farmer has a start up capital of KShs 50,000 to help him through the ten months before he begins to make major sales. Note that during the period of cash deficit, i.e., from June to September, the farmer can either 'borrow' from his other farm enterprises, such as poultry or dairy, or seek a bank overdraft.

This is a simple analysis to begin with; for larger, cost-intensive fish farms, other items can be added to account for additional inflow and outflow items. Your extension agent can work through more detailed examples with you to help you understand the fundamentals of cash flow analysis as well as analyze cash flow for your enterprise.

Uses of cash flow analyses

- Prediction of cash shortfalls
- Planning for interim financing, loans
- Assessment of the business's ability to repay loans
- Evaluation of timing of loan payments
- Prediction of future cash flow scenarios for the business
- Prediction of additional capital needed in the future

Table 5.2-1 Cash flow for a tilapia farm with two ponds measuring 800 m² each.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Beginning													
1.0 Cash	50,000	32,400	21,200	12,400	8,700	7,000	-1,900	-11,200	-22,500	-28,700	11,500	38,300	51,800
2.0 Cash Inflow													
2.1 Sales of fingerlings	0	0	2,400	6,000	8,000	2,400	2,000	0	3,600	5,000	6,600	12,000	500
2.2 Sale of food fish	0	0	0	0	0	0	0	0	0	45,000	30,000	10,000	4,000
2.3 Sale of feed bags	0	0	0	0	0	0	0	0	0	0	0	0	500
2.4 Total Inflow	50,000	32,400	23,600	18,400	16,700	9,400	100	-11,200	-18,900	21,300	48,100	60,800	56,300
3.0 Cash Outflow													
3.1 Fish seed	6,400	0	0	0	0	0	0	0	0	0	0	0	0
3.2 Fertilizer	3,000	3,000	3,000	1,500	1,500	1,500	1,500	1,500	0	0	0	0	0
3.3 Wheat bran	0	0	0	0	0	1,600	1,600	1,600	1,600	1,600	1,600	800	800
3.4 Labour	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
3.5 Home Expenses	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
3.6 Payment of loan	0	0	0	0	0	0	0	0	0	0	0	0	0
3.7 Total Outflow	17,600	11,200	11,200	9,700	9,700	11,300	11,300	11,300	9,800	9,800	9,800	9,000	9,000
4.0 Net cash	32,400	21,200	12,400	8,700	7,000	-1,900	-11,200	-22,500	-28,700	11,500	38,300	51,800	47,300