African Organic Agriculture Training Manual

A Resource Manual for Trainers

10-9 AQUACULTURE

Draft Version 1.0
June 2011

Ready for field testing

FiBL

IMPRINT

Publisher:
FiBL, Research Institute of Organic Agriculture, Switzerland, www.fibl.org

Collaboration:
- IFOAM, International Federation of Organic Agriculture Movements, Germany, www.ifoam.org
- NOGAMU, National Organic Agricultural Movement of Uganda, www.nogamu.org.ug
- FENAB, Senegal
- OPPAZ, Organic Producers and Processors Association of Zambia, www.oppaz.org.zm

Responsible author:
Andreas Stamer (FiBL)

Reviewer:
Brian Ssebunya

Illustrator:
Okudi Deogratius Gerard, Andrew Baingana

Draft version 1.0, September 2011.
This is an interim version. Comments and recommendations for improvement are welcome.

All materials resulting from the Africa Organic Agriculture Training Manual project are available free of charge in the internet under www.organic-africa.net

The production of this manual was funded by the Bill and Melinda Gates Foundation and the Syngenta Foundation for Sustainable Agriculture with the goal to promote organic farming in Africa.

Please cite this publication as follows:
FiBL (2011): African Organic Agriculture Training Manual. Version 1.0 June 2011. Edited by Gilles Weidmann and Lukas Kilcher. Research Institute of Organic Agriculture FiBL, Frick

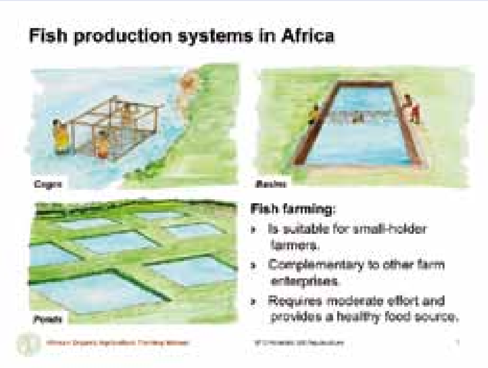
ISBN 978-3-03736-197-9

CONTENTS

10-9 AQUACULTURE

FACTSHEET 39: AQUACULTURE

FISH PRODUCTION SYSTEMS



Learning targets for farmers:

- Learn how to integrate aquaculture into the farming system
- Understand the relevance of good planning and procedure for the construction of fish ponds
- Recognize the values of farm-own feed sources
- Understand the procedure for propagation of own fish
- Learn the methods for monitoring water quality and critical indicators
- Learn the relevant criteria for organic certification of aquaculture

1. Introduction

Consumption of fish per capita in sub-Saharan Africa has lagged behind that of the rest of the world, partly due to the low supply of fish products. However, aquaculture, especially fish culture (farming), is increasing. Commercial finfish culture in fresh or brackish water is now common, with Nigeria, Ivory Coast, Zimbabwe, Kenya and South Africa being the leading producers. Marine shrimp culture is concentrated in Madagascar, although a few farms are found in Seychelles, Mozambique and Kenya. Aquaculture is estimated to be 95 percent small-scale, characterized by one or more small ponds of 100 to 500 m2 in size, with fish ponds integrated into the rest of the agricultural activities.

Aquaculture is the production of all forms of aquatic animals such as fish and crustaceans or aquatic plants such as algae in fresh, brackish or salt water. In freshwater, mainly fish and some species of freshwater-prawns are raised. Although fish can also be raised by fencing-off or using net-cages in a swamp or a lake, the most efficient way to grow most fish is in a domesticated pond system. In this chapter, we will, therefore, discuss production practices based on this system.

Fish farming in ponds offers different advantages:

- It is a suitable system for small-holder farmers especially in regions where water is available in sufficient quantities. Fish is an excellent source of protein for the family and can be supplied or sold to other people in rural areas.
- It is complementary to other farming activities. Most cultured fish species are omnivorous meaning that they are not very selective regarding their food. They can be fed on-farm products such as rice bran, leftover sugar cane, soybean cake and other remnants of plant and food production. They also feed on insects, other fish, snails or other animals that are naturally available in the pond.
- The water from the pond and pond sediments are rich in nitrogen and phosphorus and can be used to irrigate and fertilize crop gardens.

However, fish pond production varies depending on the environment and the species involved. Generally, they can be categorised depending on size and/or intensity of management as follows:

- **Small-scale aquaculture** includes extensive or semi-intensive pond production operated by the farmer and his/her household and integrated to varying degrees with other agricultural enterprises. Tilapias and/or catfish *(Clarias or Heterobranchus* species) are commonly raised with some limited carp production, mostly *Cyprinus carpio*. This scale of production primarily relies on on-farm inputs including organic fertilizers and simple supplementary feeds, and most of the labour is provided by the family. Small-scale fish production generally requires minimum capital investment and is not mechanized. Most of the fish harvest is consumed by the family and any excesses are sold to neighbouring markets.
- **Commercial aquaculture** involves large-scale production normally having a water surface area of about five hectares or more. Such production tends to be more capital intensive, relying on wage labour, external inputs and mechanization. Commercial aquaculture is common in the Ivory Coast (Chrysichthys, Clarias and tilapia), Nigeria (Clarias, Heterobranchus, tilapia and carp), Zambia (tilapia and carp), Zimbabwe and Kenya (trout and tilapia), and South Africa (trout).

Challenges to aquaculture in Africa

Aquaculture or fish farming, in particular in Africa, is still facing several challenges, some of which include:

› **Limited knowledge on fish farming -** There is a general lack of adequately trained personnel to undertake aquaculture extension activities with farmers as well as limited access to good quality information. The few trained workers are mainly employed in research while the majority still need proper orientation in practical aquaculture. Specific knowledge on pond establishment, proper feeding, health management and good harvesting and restocking practices is still very low.

› **Limited land and water resources -** In some places, there is neither sufficient land nor enough available water to support successful aquaculture. The growing concerns about environmental conservation are also limiting production systems under swampy or mangrove ecosystems.

› **High investments -** Establishing aquaculture in ponds commonly involves high investments in terms of labour for digging the ponds and the costs of maintaining the ponds. This is further worsened by the general scarcity of affordable long-term investment capital for aquaculture.

› **Limited availability of quality inputs -** The limited availability and high cost of fish stock and feed is a critical constraint to the development of aquaculture. Fish feeds like fishmeal are not easily accessible and the cost is not affordable to most small-scale producers. Access to production inputs is further limited by the poor infrastructure and poor aquaculture extension services.

On the positive side, it is generally accepted that there is significant potential for growth of aquaculture. Labour is available and economical, while the demand for fish is high and often unsatisfied. In many areas, land and water resources are still readily available and underutilised. Adoption of aquaculture is therefore a complementary means of providing better nutrition and incomes to farming households.

However, there is the need to adopt appropriate management practices taking care of environmental protection and the sustainable use of aquatic resources as well as the food safety requirements. Organic aquaculture aims at meeting these challenges and establishing a sustainable farm activity that is well-integrated into the farming system and provides safe, additional income to small-holder farmers in Africa.

Assessment of local fish farming activities

Inquire among the farmers about fish farming in the area by asking the following questions:

› What do you know about fish farming?

› Are there any farmers growing fish in the area?

› How many farmers are growing fish and how big are their farms?

POTENTIAL OF INTEGRATION OF AQUACULTURE

2. Proper integration of aquaculture into the farming system

Proper integration of aquaculture into the farming systems is the primary aim in organic aquaculture in order to ensure sustainable production. Besides this, other aims of organic aquaculture include:

- producing fish with minimal negative effects on the environment;
- producing fish that contain as low as possible levels of contaminants and chemical residues;
- raising fish while paying special attention to respecting animal care and welfare;
- feeding the fish without competing with human beings for food;
- contributing to farmer families' daily menu at low cost and moderate effort;
- entering markets and offering an attractive healthy foodstuff; and
- contributing to social development by gaining premiums that could be reinvested in the community.

Organic aquaculture relies on organic cycles, first of all on a healthy environment consisting of good quality water. The fish is raised on natural feed production, preferably farm-own by-products, homemade feeds or certified organic feeds.

The culture of *Tilapia nilotica* in ponds, fed on pelleted feeds made from locally available agricultural and industrial waste products, yielding three crops and a production of not less than 5,000 kg per hectare and year, has already been tested and found to be perfectly feasible and economical in Central African countries. When combined with duck or pig production, the income of the farmer increases two to three times. Experimental culture of grey mullets (*Mugil* spp.), tilapia (*Tilapia* spp.) and catfish (*Clarias lazera*) or common carp (*Cyprinus carpio*) in brackish water ponds in deltaic areas in Nigeria and Egypt producing about 3.500 kg per hectare, has served to show the feasibility of brackish water farming. Rice field carp culture is an established practice in Madagascar. Stocking of small dams and reservoirs with tilapia has yielded very encouraging results in Kenya and Ghana.
Source: www.fao.org

Note for the trainer:
For reasons of simplification, this training guide only refers to growing the most popular tilapia species Oreochromis niloticus, the Nile tilapia, in ponds. This species is easy to manage and is omnivorous, meaning it feeds on both plant and animal material such as algae and microalgae as well as on zooplankton, small crustaceans and insects.

2.1 Key requirements for growing fish in a pond

Digging a hole in the ground, filling it with water and throwing some fish into it will not alone lead to success. To be successful, pond fish farming requires proper planning before starting.

- **Land and labour -** Before starting, the land and labour costs need to be estimated, for example, for buying or renting the land to build the ponds on, for labour for digging the ponds, for management and for harvesting of the fish. Other costs may include buying the fish stock and feeds.
- **Suitable site -** Growing the fish in a pond requires enough water of good quality and at reasonable costs. If any permits are required to use the water, they must be obtained first. The soil at the site must be able to retain water.
- **Fish stock -** Future fish farmers need to decide whether to breed their own fish stock or to purchase it from other farmers. When purchasing the young fish from other sources, the farmer must be sure of having a reliable source of good quality fish. If he plans to certify his fish as organic, the fish shall not be modified in its genes and not treated with hormones. Both treatments are often done to obtain just male fish, and are common with tilapia. If the farmer instead chooses to breed own fish on his own farm, then sufficient space is needed to maintain production of brood stock (parent fish) and young fish (fingerlings).
- **Market for the fish -** If a farmer decides to produce fish for the nearby markets, he must be sure that his product is attractive for the shops and the buyers. And he needs to be sure that the prices he will get are reasonable enough to at least cover his production costs.
- **Proper management -** In contrast to a fisherman, a fish farmer is responsible for the growth of the fish from young stages until it reaches market size. This

Discussion on local potential of growing fish in ponds

Invite the farmers to discuss about the potential of pond farming in local context.

- Can the cultivation of fish upgrade local farms?
- Are the natural, social and financial circumstances favourable to fish farming?
- Does market demand encourage uptake of this new farm activity?
- Are there any constraints to this new activity?

means that the fish farmer needs to care for the fish and its growing environment – very similar to a farmer keeping chickens or cows. Fish farming requires spare time for monitoring several times a day.

3. Proper establishment of fish ponds

The first question related to the construction of a pond refers to the size and number of ponds needed:

› If fish production will mainly only serve household needs and the fingerlings will be purchased from a hatchery, then only two ponds will be needed.
› If a fish farming activity is intended that is independent from hatcheries, the farmer will need more ponds: (i) one breeding pond of 10 m x 10 m size and water depth of 50 to 80 cm, (ii) two or three nursery ponds of 2 m x 5 m and water depth of 30 to 50 cm, and (iii) two or three grow-out ponds of 20 m x 20 m or 20 m x 50 m with a water depth of 50 to 150 cm. In addition, it is recommended to have one stand-by pond of 10 m x 20 m and a water depth of 50 to 100 cm for special situations.

The sizes of the ponds depend on the available water per time unit and on planned extension and intensity of the future production.

3.1 Site selection for pond culture

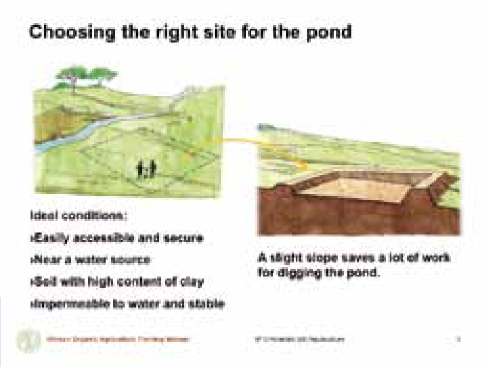
The most common and easiest system to grow tilapia is the earth pond system. Choosing an appropriate location for the ponds is essential to ensure permanent provision of water, minimize construction costs, allow easy management and avoid loss of water through seepage.

› **Location -** The fish ponds are ideally placed near the home or the village to minimize costs and effort for transport and to reduce the risk of losses from theft. The site should be accessible at all times and not subject to occasional flooding. And the ponds should not be placed next to conventional crop fields where agrochemicals are used, to avoid polluting the pond water. This also applies to the source of the incoming pond water, whether it is a stream or a well. The pond site borders should be protected with ridges, trees or bushes.

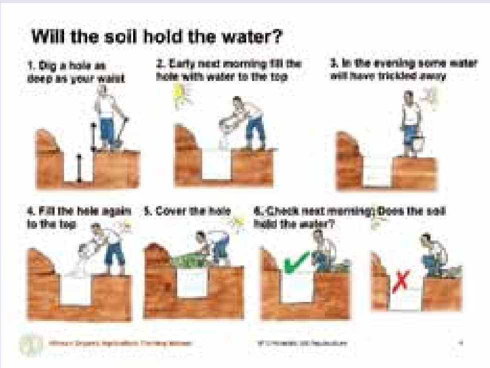
Field visit on the establishment of fish ponds

Select a nearby aquaculture farm to take the participants for a field trip. Together, study the common practices of pond construction. Discuss the types of ponds that are used locally, identifying any challenges related to local ponds

CHOOSING THE SITE FOR THE POND



SOIL IMPERMEABILITY TEST



- **Proximity to a water source -** The ponds must be situated in proximity of a permanent water source. The water source can be a spring or a small stream. The minimum amount of incoming water should be about 10 litres per second for a pond of about 100 m x 100 m and a water depth of about 1 m. Water losses by evaporation must be considered. In general the annual water requirement to compensate for the losses by evaporation is nine times the volume of one pond filling. Make sure that the water is available all year round.
- **Topography -** Ideally the ponds are placed on a slight slope. This will save a lot of digging work to make the pond. A slight slope of 1 to 4 % is advantageous (a 1 % slope corresponds to 1 cm of height on a distance of 1 m).
- **Soil properties -** The permeability of the soil must be minimal to ensure minimum water losses through seepage. To be water impermeable and remain stable when flooded, the soil must have a high content of clay. A soil consisting of silt, which has the second smallest soil particles, is also mostly water impermeable, but it can become unstable when flooded.
  There are three methods to test the suitability of the ground:
  (i) Seepage test - Dig a hole and see, if the soil holds the water overnight to at least 90 %.
  (ii) Press some soil in the hand to see if its stability is good.
  (iii) Rub the soil between your hands to distinguish between clay and silt. If all tests are positive, you can begin to plan the dimensions of your ponds.

3.2 Pond construction

a. Pegging of the pond area

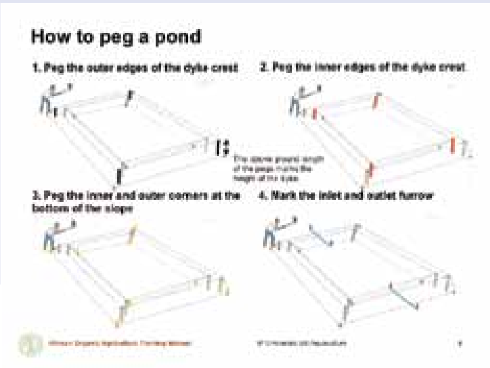
Once the site and the size of the pond have been defined and soil properties have been tested, the position of the edges of the pond and the height of the dyke are marked with pegs. The size of the pond should be about 10 m x 10 m and the water depth 50 to 80 cm. The bottom should be covered with sand or gravel.

Before placing the pegs for the pond, it is important that the area is cleared from big rocks, trees and bushes.

- The first pegs placed should be the ones at the outer edges of the dyke's crest. The above ground length of the pegs marks the height of the dyke. The height of the dyke on the inlet side of the pond must be at least 1 m high.

STABILITY TEST

PEGGING OF THE POND



- A second grid of pegs should mark the inner edges of the dyke's crest at a distance of 1 to 2 m from the pegs marking the outer edges. All the upper ends of the pegs of the first and the second grid must be aligned horizontally. This can be made by connecting the tops of the pegs with a rope and using a water level.
- A third and a fourth grid are used to mark the outer and inner bottom edges of the dyke's slopes using short pegs.
- At last the inlet and the outlet furrow are pegged.

b. Construction of the dykes

The top of the dyke must have the same level all around the pond and should be about 0.5 m higher than the water level. If the pond is built on a slope the height of the dyke will be less at the low water side and more at the deep water side. For example, if the area has a slope of 2 %, the bottom of the pond in a distance of 50 m from the inlet would be 1 m deeper without needing to dig (because 2 % of 5,000 cm is 100 cm). If the water level at the shallow end is 0.5 m, it will be 1.5 m at the deep end. That means the dyke will be 1 m at the low water side and 2 m at the deep water side.

The dykes of the pond must be water impermeable to prevent seepage and to remain stable. The material for dyke construction is ideally the material a farmer gets when digging out the pond. If the soil does not consist of mainly clay, a core trench should be built in the centre of the dyke.

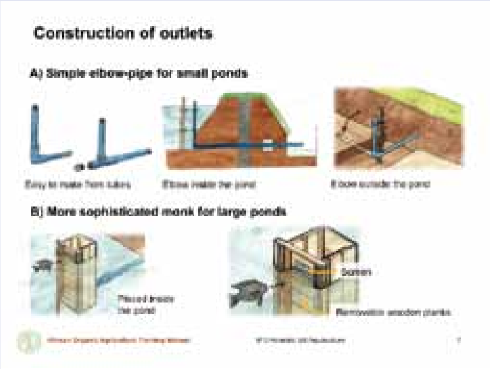
The inlet furrow, which leads the water from the source to the head of the pond, needs a slope of at least 0.2 to 0.5 % to assure a good current of the incoming water. Ideally the inlet ends in a cascade or a fountain to oxygenate the water. The inlet can be designed as an open channel or as a submerged pipe. Open channels should be covered by stone plates in proximity of the pond to allow easy working.

At the deep-water end of the pond an overflowing pipe with an elbow joint leading to the outlet furrow or a monk must be constructed before building the dyke. Both serve to regulate the water flow going in and out of the pond. The outlet of a small pond can be realised as an overflowing pipe. If the upright part of the pipe is situated outside the pond, the water level can be easily regulated. This is very helpful in nursery ponds. In large ponds, monks made from wood or concrete are common, where the water level is regulated with wooden boards. All inlet and outlet pipes must be covered with suitable screens to prevent the

Practical testing of soil samples

Bring different soil samples along to show the differences in properties. Ideally, bring a sample of clay soil, silt soil and sandy soil along and let the participants apply the different tests.

CONSTRUCTION OF THE OUTLET



POND CONSTRUCTION (1)

fish from escaping and foreign fish from entering the pond. The screens must be cleaned regularly to guarantee accurate water flow.

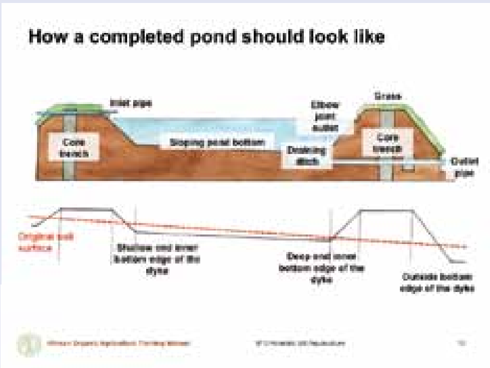
c. How to proceed for pond construction

To get material for the dykes and to make the pond deeper, the farmer must dig about 30 to 50 cm of soil from the interior of the pond and from the outlet furrow.

1. First the top layer of the soil containing roots and leaves is removed and is deposited outside the pond area. It can be used later to cover the dykes for planting grass.
2. In a second step the inlet ditches are dug to 1 m in front of the dyke (near the inlet pipe) and about 1 m from the place where the water is collected. After finishing all of the digging work, a sluice needs to be constructed and inserted into the ditch to be able to control the water flow. When all construction work is finished, the earth bridge between the pond and the sluice is removed and the water from the stream is lead into the inlet furrow. By putting different boards into the slots of the sluice one can control the water flow into the pond. An additional screen can prevent wild fish from getting into the pond.
3. If the soil does not consist of mainly clay, the dyke can be made more stable and impermeable by thoroughly compacting pure clay taken from another place in the centre of the dyke, repeatedly building a core trench. The trench must be dug into the ground before the walls of the dyke are piled up.
4. The trench is built above ground using wooden boards for planking. The soil inside the pegs is dug out, marking the inside banks at bottom level by layers of 20 cm at the upper end to 30 cm at the lower end. The soil is used to buildup the banks layer by layer, packing it tightly.
5. Forming the inside and outside slopes of the banks. The inside slopes of the dyke shall slope less than the outside. The dykes of medium or large ponds should be about 1 to 2 m in width on top. The inside slopes of the dykes must be built in the proportions of 1:1.5 in the case of clay and 1:2 in the case of a clay/sand mixture. That means in pure clay soil the pond faced foot of the dyke needs to be 1.5 m long if the dyke is 1 m high. The outside wall of the dyke could be steeper: 1:1 in clay material and 1:1.5 in the case of clay/sand mixture.
6. After forming the dykes the top side and the outside slopes are covered with the topsoil that was removed first.

POND CONSTRUCTION (2)

COMPLETED POND



7. Bottom of the pond: The bottom of the pond should have a slope of 1 to 2 % to allow complete drainage for harvest. Instead of creating a continuous slope the farmer may dig a depression near the outlet on the bottom of the pond to enable easy and gentle harvest of the fish. Such a depression does, however, have the disadvantage that the pond cannot be completely emptied. The location and the shape of the pond can be chosen in accordance to the topography to minimize the work for digging.
   The bottom of the pond can be treated with slaked lime or quicklime and agricultural lime to make the nutrients in the soil soluble and sanitize the pond bottom. The lime must be thoroughly ploughed into the upper layer (5 to 10 cm) of the soil. The use of chlorinated lime is not allowed in organic aquaculture. The amount of lime needed depends on the pH of the soil and the kind of lime to be used.
8. After all earthworks have been completed, the bottom and the inner slopes of the dykes might be stamped again.

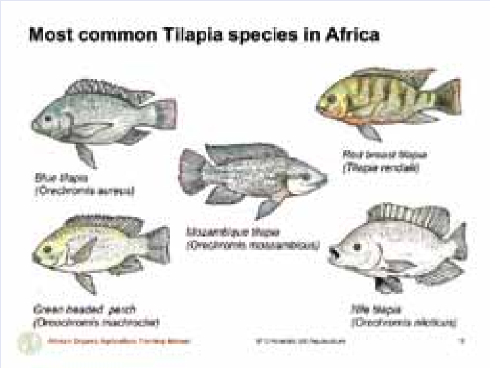
3.3 Filling of the pond

Filling the pond with water will take some days or weeks, depending on the flow of incoming water and the volume of the pond. After filling the pond completely, it must be checked for possible water leaks. The farmers must make sure that the inflow and the outflows are accurate and that no material is clogged in the screens and that the pH of the water is balanced.

Within a few days water turbidity should decrease as the particles settle. If the incoming water is very turbid, a siltation tank is needed in front of the water inlet to the pond to allow the particles in the water to settle.

Microalgae and other microorganisms will then rapidly develop, turning the water's colour from muddy brown or colourless to green. The extent of algae growth reflects the nutrient load in the water. It can easily be assessed by measuring the turbidity of the water using what is known as a *Secchi disk (see transparency 15)*. When the water has developed a stable chemistry and colour, the first fish can be added to the pond.

DIFFERENT TYPES OF TILAPIA



3.4 What fish to use?

The choice of species for culture is of special importance. The most common fish for extensive or semi-intensive aquaculture in Africa is tilapia. The name refers to a whole group (tribe) of fish living in very different biological surroundings. Tilapias are indigenous in Africa, but only a few of them are really suitable for farming. The most common tilapias used in fish farming are: Nile tilapia *(Orechromis niloticus)*, Mozambique tilapia *(Orechromis mosambicus)*, blue tilapia *(Oreochromis aureus)*, green headed perch *(Oreochromis machrochir)*, Zillis perch *(Tilapia zilli)* and red breast tilapia *(Tilapia rendalli)*. Other popular fish grown by African farmers are the African catfish *(Clarias garipinus)* and other species of catfish and different species of carps *(Cyprinus carpio)*.

The species chosen for fish farming should ideally be easy to manage, popular for consumption, available as stock in the region and should grow well under local climate conditions. In this chapter, we recommend to work with tilapia species and refer to the most popular species *Oreochromis niloticus*, the Nile-Tilapia. This species is easy to manage and is omnivorous (i.e. it feeds on algae and microalgae as well as on zooplankton, small crustaceans and insects). In Eastern Africa, *Oreochromis* species might be more popular than the *Tilapia* species, whereas in the western African countries the trend is opposite.

Species selection also depends on local climatic conditions. Some species reproduce almost all year long if the minimum water temperatures are reached while others do have distinct spawning seasons depending on the water temperature. Some species need high temperatures (26 to 30° C) to grow well, other species do well at moderate temperatures around 22 to 24° C. In addition, hardiness and oxygen demand vary among the species.

4. Appropriate stocking of the pond

Depending on the available feeding resources, 2 to 4 fish per m^2 of pond area are appropriate with a sex ratio of one male per 4 to 5 females. The male fish should weigh 200 to 300 grams, the females 700 grams or more.

In most *Orechromis* species, the male fish grow bigger and faster than the female fish. This is one reason why it is recommended to work with just one sex per pond. Another reason is that mixed populations will propagate very early in the

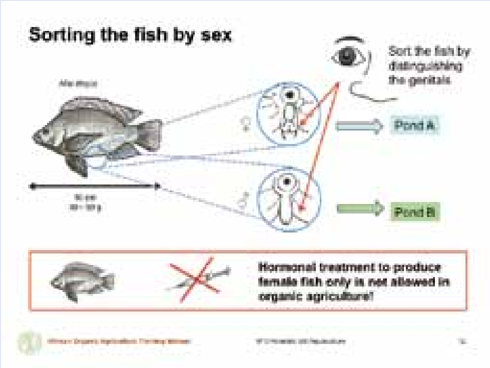
Discussion on suitable fish species

Inquire among the farmers about the locally grown fish species by asking the following questions:

- Which type of fish is commonly grown in the region?
- What are the characteristics of these fish and what is the preferred species?

If possible, invite an experienced fish farmer to share his or her experiences with the preferred fish species.

SORTING THE FISH BY SEX



pond leading to what is called ***stunning of the production***. The juveniles and fingerlings will compete for the feed with the adult fish, which will result in much smaller fish. If only males are grown, the female fish are either culled after sexing or raised separately in another pond.

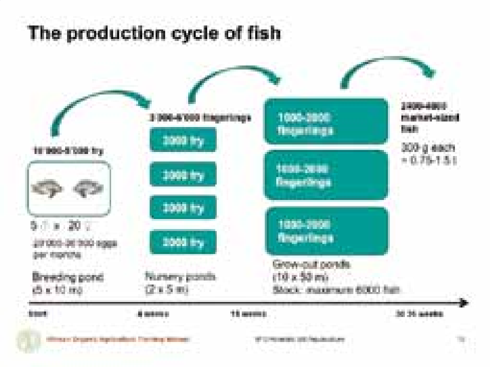
In organic pond farming, there are two possibilities to obtain very high rates of one sex:

› The first one is to cross two different tilapia species to obtain hybrids. If a particular species is used, the offspring can be up to 100 % males. One example is to mate female ***Orechromis mossambicus*** with male ***Oreochromis urolepis hornorum*** to achieve what is known as Malacca hybrid.
› The second possibility is the selection of the fingerlings manually by checking their genital papilla, when the fish are about 10 cm in size. At this size, Nile tilapia can be differentiated on the basis of the genital papilla. This is very labour-intensive and requires some experience, but has the advantage that the farmer does not need to keep different species as brood stock.

If the farm fish production relies on purchased fingerlings from hatcheries, the farmer must make sure that the tilapias (especially ***Orechromis*** species) were not given any hormones. Hormonal treatment is not allowed in certified organic farming. Hormones are commonly fed to produce male fish only, as male fish, especially in tilapia, tend to grow bigger and faster than females. If the farmer cannot buy mono-sex fingerlings that are guaranteed not to have had hormonal treatment in the past, he would need to buy mixed sexes or run his own breeding.

A good way to control unwanted juveniles in the pond is to put some predator fish in the pond (for example, African catfish ***Clarias gariepinus*** or snake head ***Ophiocepalus*** spp.). The predator fish shall not be bigger than double the size of the smallest tilapia. No more than five percent of the entire fish stock in a pond should be predator fish. For example: if the farmer has a 'standard pond' of 100 m^2 (10 m x 10 m), the farmer can stock it with 200 to 400 fish in the beginning, depending on his external feed availability. That means at low stocking density (with little or without external feeding) he can put 190 tilapia fingerlings of 10 to 12 cm and 10 catfish or snakehead fish of about 20 cm into the pond, or 380 tilapia and 20 prey fish, if he chooses to have high stocking density (and has the possibility for sufficient external feeding).

PRODUCTION CYCLE OF FISH



5. Propagation and fingerling production

Tilapia fish breed very easily in breeding ponds. Adult fish will begin mating soon after they are released into ponds, provided that the water temperature is between about 25 and 30 °C.

Feeding - The fish should be in good condition before being stocked to the pond. Only some feed, preferably high in protein and fat, is needed for the fish in the breeding ponds, as the females do not eat during the breeding phase. The breeding ponds can be fertilized like the big ponds to enable the development of food organisms for the adult fish and the young fry.

Harvesting - Females weighing 700 g or more will spawn about 1200 to 1500 eggs, which results in about 1000 juveniles per female fish. A first harvest of juveniles is possible three to four weeks after stocking using a small mesh-sized net. Harvesting is repeated every one or two weeks. Only juveniles that do not pass a 1 cm mesh are harvested. Every four to six weeks all juveniles need to be caught out of the breeding pond and the smallest must be sorted out and killed. A humane method of killing them is by throwing them into iced water.

Nursing - Fry that are big enough, are transferred to small and shallow nursery ponds where they feed on natural pond production. That is why the nursery pond needs to be fertilized like the breeding ponds to enable the development of feeding organisms for the young fish. Additional feed can be given at a daily rate of 4 to 10 % of the body weight until the fish are about 20 to 30 grams. Weighing the fish once a week is needed to calculate the amount of feed necessary. The stocking density of a nursery pond could be about 300 to 500 fish per m². The density depends on the amount of feed and water that is available. When the fry have developed to fingerlings of about 10 cm in size, they can be transferred to the grow-out ponds. During growth in the nursery pond, the smallest fish need to be sorted out every three to four weeks. At the end of the nursing period they can be differentiated between male and female sex to achieve mono-sex cultures. Forty female fish in a standard breeding pond will produce approximately 20,000 fry per month, leading to at least 3,000 to 6,000 fingerlings.

6. Minimizing feeding costs

Feed is one of the most important factors influencing the growth and health of the fish. Minimizing feeding costs is thus of great interest, while ensuring sufficient good quality feed to ensure appropriate growth and good health of the fish. Tilapias can basically be fed by fertilizing the pond with animal manure or plant materials and encouraging the development of microalgae and other microorganisms in the water. Appropriate growth of microalgae and other microorganisms offers a valuable source of feed and results in increased fish yield. This is why integration of aquaculture with other animal keeping activities is quite popular in the tropics. It also helps to reduce the feeding costs considerably. To fertilize the ponds, manure from cattle, pig or poultry are used to either fertilize the bottom of the ponds prior to filling or to enrich the pond water with nutrients by continuously adding manure to the water. Based on pond manuring, the fish yield can be estimated to about 30 to 50 kilograms per 100 m^2 per year.

Feeding artificial feeds (including fishmeal or fish oil) could make the fish grow faster, but these feeds are expensive and may be difficult to purchase in organic quality (in case of organic certification).

a. Fertilizing the pond through integration of animal keeping

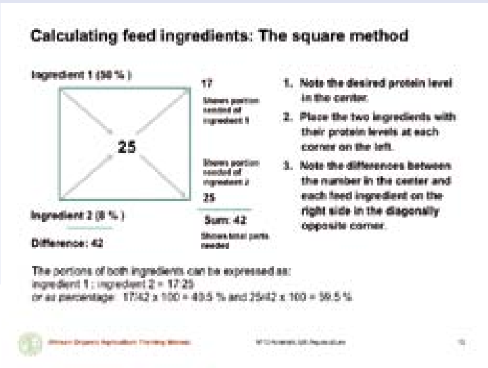
Keeping waterfowl is an uncomplicated and natural way of manuring the pond. Ducks and geese are attractive and especially suited fowl for small-scale farmers. Within one year about 120 to 150 ducks can be raised on 100 m^2 of pond with one growth cycle of the ducks being 2 months. During this period the ducks produce approximately 4 to 6 tons of manure. The birds can be fed on water hyacinth, cereal by-products, kitchen wastes or other vegetal feed. To balance fish and duck husbandry, the fish to duck ratio should be about 200 to 20 or 30 per 100 m^2; and if geese are kept, 10 to 20 animals are ideal with 200 fish per 100 m^2.

Animal manure from cattle, pigs or poultry can be added to the pond directly, but because of hygienic reasons, previous composting is recommended. Staggered preparation of compost on separate piles offers the possibility of continuous fertilization of the pond.

Manuring of the pond should be done regularly with small amounts, instead of throwing a big amount of manure into the pond once a month. This is essential to avoid depletion of oxygen in the pond water. The best time to add manure is one or two hours after the morning feeding. Manuring after sunset must be

APPLICATIONS OF COMPOST AND MANURE FOR POND FERTILIZATION

CALCULATING FEED REQUIREMENTS – THE SQUARE METHOD



avoided to prevent oxygen depletion due to combined oxygen consumption by algae in the dark and oxygen consumption by bacteria and fish. The site of manuring should be different from the feeding location.

b. Feeding the fish through integration of plant production

Alternatively to or in addition to adding manure to the pond, materials of plant origin can be used to feed the fish on a low production intensity level. Farm-own vegetal feeds include leftovers from fruits such as papaya or mango. Leaves and other vegetal material are best used to prepare compost with animal manure. In case fish production is certified as organic all external inputs must come from an organically certified farm. The leftovers from processing cereals and soybeans, etc. can either be added to the pond directly, which is much better, or they are processed to pellets.

There is a variety of plants that can be used for additional fish feeding. Some examples include rice bran, soy press cake, sunflower press cake, cassava leaves and roots, sorghum remains after pounding and maize (corn) milling remains.

When feeding the fish with plant material, attention must be paid not to spoil the pond water with too much plant material. Plant material which is not eaten by the fish directly or within a short time, will increase microalgae production and increase turbidity of the water. Fish farmers thus must keep a constant eye on water turbidity and the behaviour of the fish.

Homemade feeds

Remains and by-products from foodstuffs such as rice bran and soy press cake and other ingredients such as macroalgae must be dried, grained and stored separately, to avoid rapid spoilage due to high fat content. To produce the fish feed, a blend of all meals must be carefully mixed with water to get a paste that could be processed to pellets in a simple pellet press. The mixture of the different meals must contain approximately 1/3 cassava meal to obtain good water stability after drying the pellets in the sun. The mixture of the ingredients must also have a high protein content of 25 to 30 % or more. With the square method the ratio of two different ingredients with known protein contents can be calculated easily.

If farm-own inputs are not available to make the pellets, farmers can rely on the pond's own production (and support it with fertilizing inputs or food leftovers from neighbouring farmers, if available) or they can use commercial compound feed. Commercial feed should be a tilapia-suitable feed with low or no fishmeal content. If farmers aim to sell their fish as organic at a regional market, then they must use an organically certified feed, which might be difficult to obtain. If they have the possibility to cooperate with a fish-feed producer, they can try to get a compound feed that complies with organic requirements. Such feed must be composed of GMO-free raw materials that has not been treated with pesticides, fungicides or the like and produced in accordance with organic regulations. Compound feeds have the advantage that they are more easily digested and healthier than most of the homemade feeds or feed made from a single by-product (e.g. rice bran). The cost of such feed is higher, but the result of the farm (the volume of the annual harvest) might get much better.

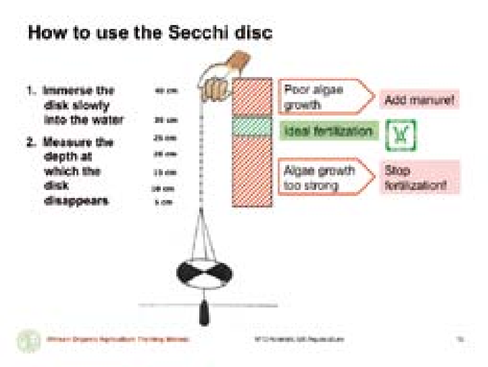
How to calculate feed requirements?
By knowing the number of fingerlings that are stocked to a pond, the farmer can calculate the fish biomass in the pond at a certain time, based on the average weight of the fish. Such monitoring is important to determine the correct amount of feed needed for the fish. For example, 5 % of the bodyweight in feed makes 4 kg of feed at the beginning of the growing period (calculating on base of 4,000 fingerlings of 20 g each) and about 55 kg at the end of the growing period (calculating with 3,600 adult fish of 300 g each). During the growing period of approximately eight to ten months, this increase in body weight and feed requirement is not linear, but follows a curve that could be determined by frequently weighing the fish.

7. Monitoring water quality

Regular monitoring of the water quality is important to ensure ideal living conditions for the fish.

Turbidity of the pond water - This gives information about its nutrient status. Turbidity is measured using a Secchi disk. The disk is made of metal or plastic (if it is plastic, a weight under the disk is needed to make it sink in the water) and can be white or black and white. On the cord, which holds the disk, there are nodes every 5 cm on the first 50 cm and every 10 cm on the next 50 cm. The disk is immerged slowly into the water and the number of immerged nodes is then counted. The depth, at which the disk disappears when we look at it from the wa-

HOW TO USE A SECCHI DISC



ter surface, is called the Secchi depth. An ideal value is between 25 and 30 cm. If visibility is as deep as 40 cm, 50 cm or deeper, algae growth is poor and should be enhanced by adding organic manure. If visibility is below 25 cm, algae growth is too strong and can result in low oxygen content in the water during the night. In this case, feeding and manuring must be stopped for some days until the Secchi depth has reached 30 cm again.

Oxygen - Depletion of oxygen is the most common reason for losses in the fish pond. If algae growth in the pond is very strong, the oxygen content during the day is high, since algae produce oxygen through photosynthesis. But during the night, the algae competes with the fish for oxygen and its content decreases to a minimum level in the very early morning before sunrise.

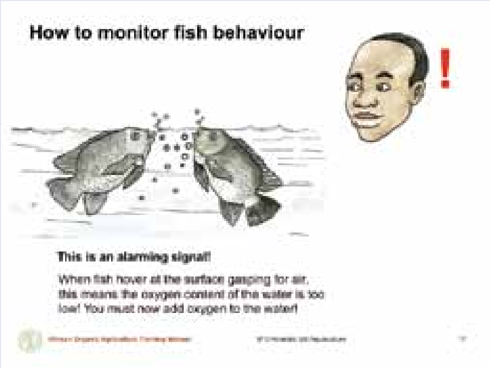
If the growth of the algae is ideal (Secchi depth of 25 to 30 cm) and if there are not too many fish in the pond and the fish are small, oxygen saturation of the pond water should be sufficient. Competition for oxygen between fish and all other organisms in the pond can become a serious problem, however, if the stocking density is too high and the fish get bigger.

If the farmer has a means to control the oxygen-concentration in the water, he should do it twice or three times a day, when the fish show occasional gulping behaviour. Gulping usually appears when oxygen content falls below 1 to 2 grams per litre. Oxygen should be measured early in the morning before sunrise and half an hour after feeding in the afternoon or evening.

pH-value - The pH value gives information on the acidity of the water. A pH of 7 means that the water is neutral and does not have acid or alkaline characteristics. This value is ideal for fish and algae. The pH can be determined with colour tests, available as liquid tests or as a blotting paper test. Values below pH 5 can be corrected with careful addition of lime-milk and through a reduction in the stocking density. Reducing stocking density also helps if the pH is very high (above 9).

Toxic substances - Many chemicals used in animal husbandry and crop production on non-organic farms are poisonous to fish. Such chemicals and synthetic medicines should never be used in proximity of the pond. Prevention is crucial in this regard. Any existing or potential source of water pollution must be thoroughly investigated. If contamination is suspected, analyses of the water and the fish must be done by sending samples to specialized laboratories.

MONITORING FISH BEHAVIOUR



7.1 Monitoring fish behaviour

Monitoring the behaviour of fish during and after feeding and also during and after dispersing manure into the water gives some indication of the well-being of the fish.

If the fish hover near the surface of the water and gasp for air, this means that the oxygen content of the water is too low and they are slurping air and surface water to get more oxygen to their gills. Fish often begin gulping directly after feeding. Under ideal conditions, the symptoms disappear within minutes. But if the fish show gulping behaviour for a longer time after feeding, oxygen content of the water must be increased. when this is the case, feeding and manuring must be stopped and the flow of incoming water must be increased, and/or the water needs to be aerated, for example by turning on a paddle wheel.

To prevent losses from lack of oxygen, the initial stocking density should not be higher than four fingerlings per m^2 of the pond area. In case of low oxygen content, a part of the fish stock can be brought to another pond if possible.

Recommendations to farmers regarding monitoring of fish growth:

- To monitor the development of the fish stock and estimate the proper amount of feed in case of feeding external feeds, frequently catch some fish and measure their length and weight using a yard stick and a scale.
- Prepare a bowl with water, put it on the scale, add a number of fish and get the total weight of all fish. The division of the total weight by the number of the fish will give the average weight.

Measuring several samples will give a more accurate result. Measuring must be done once a week and must be recorded in a farm book.

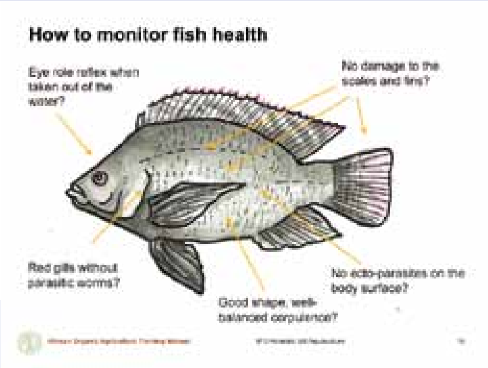
7.2 Monitoring fish health

Along with the frequent sampling of some fish to determine their size, the fish can be checked for their health status. Tilapias are very hardy fish and seldom show signs of disease. Good nutrition and good water quality with plenty of dissolved oxygen are key factors to ensuring strong and healthy fish.

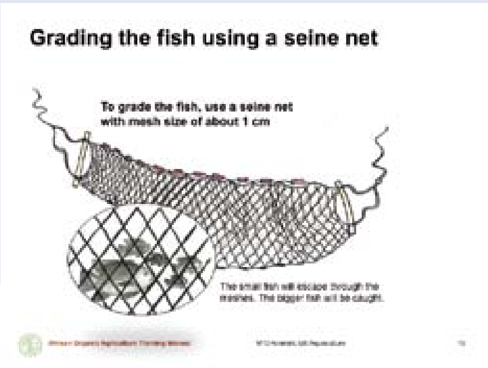
Discussion on monitoring fish behaviour

Find out from the participants, if it is a common practice in the area for farmers to monitor fish performance. Discuss the advantages of regular monitoring of fish behaviour and determine together the most critical growth stages or seasons to monitor fish behaviour.

MONITORING FISH HEALTH



GRADING OF FISH



Observation of the direct feeding behaviour of the fish gives information about the well-being of the fish as well. If the fish always come to the water surface when the farmer spreads the feed, this is an indication that they feel well. If they do not come during feeding, this could be a hint that something is wrong. In this case, the farmer should stop feeding the fish for one or two days and examine some individual fish. The caught fish then should be checked for ecto-parasites and their gills for parasitic worms.

When checking the fish for health, the following criteria should be looked at:

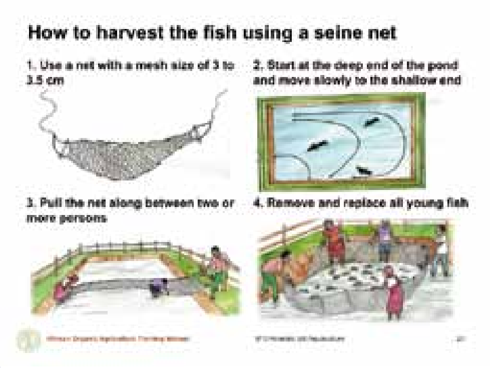
› Good shape and no skinny fish (well-balanced corpulence)
› Eye role reflex when taken out of the water
› No damage to the scales and fins
› No ecto-parasites (parasitic crustaceans) on the body surface
› Red gills without parasitic worms

If any health problems are found, action must be taken immediately. Ecto-parasites can be treated with salt baths (2 to 3 % salty solution) for 20 minutes. In case of strong mortality in one or many of the ponds, the farmer needs to get help from a microbiological lab to find out the reason. Most likely the fish will need treatment with medicine with the help of a veterinarian.

7.3 Separation of different fish sizes

Most fish tend to show different sizes several weeks after initial stocking. Some fish are dominant and get more feed and grow faster, then get even more dominant, therefore getting even more feed and growing faster. So the smaller fish seldom have a chance to catch up. To overcome this, the fish can be sorted or graded once or twice during the nursing period and the grow-out period. Practically, this is done by selective netting using a seine net with a mesh size that selects only the bigger fish. For this purpose, the selective seine net should be pulled through the pond three times. Another possibility for grading the fish is to net all fish from the pond and to sort them with a grid. If the farmer cannot work on a dyke between two ponds, he must work quickly and needs big bowls or a wheelbarrow.

HARVESTING OF FISH USING A SEINE NET



8. Harvesting and handling of the fish

When harvesting fish, we always must keep in mind that they are—like all other vertebrates—animals that experience pain and fear if they are mistreated. Thus the fish need to be handled with care and respect, especially in the context of organic farming, and harvesting must be done as gently as possible.

A seine net, which is pulled by two persons along the complete pond, is one of the best solutions for harvesting larger numbers of fish and causes little stress and panic among the fish. If the water level of the pond can be lowered, this makes the job for the fish farmer easier. If the pond can be emptied to a harvesting depression near the outlet, the fish can be caught using a scoop net. When the fish realize, however, that their space to move around in is getting continuously smaller, they inevitably panic. This means that quick action is required.

If there are many fish, harvesting the fish out of the filled seine net or out from the harvesting channel with the help of a scoop net should be done by several people simultaneously. From the pond, the fish must be transferred to a clear water tank or to a transport tank in case they shall be transported to a slaughter house.

If it is not intended to transfer the fish alive to another place, the fish must be killed immediately after being taken out of the water with the scoop net. It is unacceptable to let the fish die slowly outside the water by suffocation. The best way to kill small and medium numbers of fish is to strike them by a blow on the head using a beating wood.

If ice is available to make water/ice-slurry, then bigger numbers of fish can be transferred at once into a prepared tank. To prepare the slurry, one part crushed iced is mixed with one or two parts water. The ice should not melt completely. When the fish are transferred from the pond water (~30 °C) to the ice slurry (~0 °C) they will be anaesthetised almost immediately. But as they are not yet dead, they must be killed by a gill cut to let them bleed out.

Prevention of bad taste

Tilapia sometimes tends to have an off-flavour or muddy taste that mostly comes from the consumption of specific algae (known as 'blue-green algae') that grow in the pond. It is difficult to control these algae, but the muddy taste of the fish can be reduced by transferring the fish for two or three days to a tank or basin with a good supply of freshwater and air before harvesting. During this time, the fish do not get fed.

Discussion harvesting fish

Determine with the farmers what the most common methods of fish harvesting are. Discuss the different methods, looking at their advantages and disadvantages. Together, choose the most friendly and non-wasteful methods that can be recommended for organic fish farming.

The necessary water flow depends on the number of fish in the tank and the water temperature. If the stocking density in the tank is 30 kg per cubic meter, the water flow must be sufficient to exchange the water in the tank once every five to ten hours. In addition, a blower should bring additional air to oxygenate the water. For example, if the stock of fish that was harvested is 300 kg (this might be around 800 fish with an average weight of about 350 grams), then the tank the fish are kept in should have a capacity of about 10 cubic meter (10,000 litres). The flow of water therefore should be between 2,000 and 1,000 litres per 5 hours. This corresponds to about 7 litres (1st day) to 3.5 litres (the following days) per minute. If less water is available, only smaller batches of fish can be kept in the tank (meaning lower stocking density).

Prevention of bad taste

Tilapia sometimes tends to have an off-flavour or muddy taste that mostly comes from the consumption of specific algae (known as 'blue-green algae') that grow in the pond. It is difficult to control these algae, but the muddy taste of the fish can be reduced by transferring the fish for two or three days to a tank or basin with a good supply of freshwater and air before harvesting. During this time, the fish do not get fed.

The necessary water flow depends on the number of fish in the tank and the water temperature. If the stocking density in the tank is 30 kg per cubic meter, the water flow must be sufficient to exchange the water in the tank once every five to ten hours. In addition, a blower should bring additional air to oxygenate the water. For example, if the stock of fish that was harvested is 300 kg (this might be around 800 fish with an average weight of about 350 grams), then the tank the fish are kept in should have a capacity of about 10 cubic meter (10,000 litres). The flow of water therefore should be between 2,000 and 1,000 litres per 5 hours. This corresponds to about 7 litres (1st day) to 3.5 litres (the following days) per minute. If less water is available, only smaller batches of fish can be kept in the tank (meaning lower stocking density).

Assessment of marketing potential for organic fish production and of organic certification

Assess the market situation of fish products in the area by asking the participants the following questions:

- Is consumption of fresh, dried or preserved fish popular in the area?
- Who are the main buyers of fish? Are they interested in organic fish?

9. Marketing and organic certification of fish production

If a farmer intends to sell his fish on a local, regional, national or international market as 'organically certified', he must fulfil all requirements of organic aquaculture production and undergo inspection and certification by an independent certification body. If a farmer wants to export his products, he should supply his fish products to bigger companies or producer associations, as they are familiar with the rules of major markets. Even the local market for organic fish can be developed to target those customers that require sustainably produced fish products.

However, organic certification requires some planning and involves additional costs for inspection and certification. If the fish are to be sold as organic, all production steps need to be inspected regularly by an official inspection body. If fish production is managed without external feeding, the requirements are fairly easy to realise. The more complex the production regime, the more complex certification will be. Other costs come from the need to use certified organic feeds, if any are used. Even if a farmer relies on external feed sources of by-products like rice-bran, tapioca starch or press-cake from vegetable oil production, these sources need to be integrated in an organic production cycle. This means that all external feed to the fish production needs to be checked regularly by an inspection body. Small enterprises, which produce smaller volumes of fish, can collaborate together in a producer organisation and establish an internal control system (ICS). This can take some time to be instituted, often several weeks or months.

The main concerns organic certification in fish production includes:

› Feeding sources
› GMO-free production
› No use of hormones
› No prophylactic use of antibiotics and other medicines
› No negative effects or at least minimum possible effects on the environment
› No production in areas with risk of contamination (e.g. intensive conventional production of cash crops like cotton nearby)
› Setting up an organic management plan including environmental concerns
› Keeping of production records
› Processing the fish according to organic rules

Sources and further reading

- Food and Agriculture Organization of the United Nations (FAO). 1994. Handbook on small-scale freshwater fish farming. FAO Training Series, No. 24. Free download from: www.fao.org/docrep/T0581E/T0581E00.htm
- Food and Agriculture Organization of the United Nations (FAO). 1986. Manual of running water fish-culture. ASEAN/SF/86/Manual No. 1.
- Free download from: www.fao.org/docrep/field/003/ac415e/AC415E00.HTM
- Agromisa Foundation and CTA, Wageningen, 2008. Small-scale freshwater fish farming. Agrodok-series No. 15. Free download from: www.agromisa.org › Publications
- Agromisa Foundation, Wageningen, 2004. On-farm fish culture. Agrodok-series No. 21. Free download from: www.agromisa.org › Publications
- For links to further resources see: http://journeytoforever.org/farm_pond.html