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

Prepared by:

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January 2020

FOREWORD

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

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

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

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

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PREPARATION OF THIS MANUAL

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

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

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

ACKNOWLEDGEMENTS

The Tilapia Seed Project team wishes to acknowledge the financial support of NWO-WOTRO Science for Global Development (The Netherlands), and the CGIAR Research Programs on Policies, Institutions and Markets (PIM) and Fish Agri-Food Systems (FISH). The team also wishes to acknowledge the contribution of consortium members, *vis*: International Food Policy Research Institute (IFPRI, USA), CISR-Water Research Institute (Ghana), KIT Royal Tropical Institute (The Netherlands), WorldFish (Malaysia), Fisheries Commission (Ghana), Crystal Lake Fish Limited (Ghana) and S-Hoint Limited (Ghana). Finally, we acknowledge cooperation from public (CSIR-WRI-Aquaculture Research and Development Centre in Akosombo, Pilot Aquaculture Centre in Kona-Ashanti, and Aquaculture Demonstration Centre in Ashaiman-Greater Accra) and private farms (University of Ghana Cage Fish Farm in Kpong-Eastern and Volta Tilapia Farm in Kpeve-Volta) whose facilities were used for experimentation and practical training.

ISBN: 9964-85-286-X

CSIR Library no.: CSIR/WRI/MA/SKA/2020/1

DOCUMENT CITATION

Agyakwah, S.K., R. Asmah, E.T.D. Mensah, C. Ragasa, S. Amewu, N. Tran, M. Oyih and P. Ziddah (2020). Farmers' manual on small-scale tilapia cage farming in Ghana. ISBN: 9964-85-286-X. CSIR-Water Research Institute, CSIR/WRI/MA/SKA/2020/1. Accra, Ghana. 28 pp.

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1.1 What is cage fish farming?

Cage fish farming is the growing of fish in cages. A cage is totally enclosed on all sides (or on all sides but the top) by mesh or netting.

1.2 Importance of cage fish farming

i. For income generation
ii. For employment/job creation
iii. To satisfy nutritional needs
iv. For food security and health
v. As an alternative source of fish production
vi. As an additional *in situ* use of large water bodies

1.3 Planning a cage fish farm

In order to begin farming, you should:

i. Locate a suitable water body to install your cage (it should be at least 8 metres deep);
ii. Identify an adjoining piece of land or site not earmarked for another activity;
iii. Identify potential sources of inputs such as fingerlings and feeds;
iv. Obtain access to farm equipment such as cages, scales, boats, water quality kits, bowls, scoop nets, farm structure, feed storage room, feeding kits, graders, etc.;
v. Find buyers who will purchase your fish when they are ready to be sold;
vi. Speak to a fishery officer or an Extension Officer/source of technical information (if necessary);
vii. Develop basic fish farming skills;
viii. Make sure that you have a reliable source of capital;
ix. Develop a business plan.

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

i. The size of the fish market (how much fish customers will buy from you in a period (e.g., one year));
ii. The annual availability of good quality water;
iii. The availability of capital (money) for the aquaculture business.

1.4 Know your fish

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

i. Growth rate;
ii. Reproductive behaviour;
iii. Nutritional requirements;
iv. Market value;
v. Ability to withstand environmental conditions;
vi. Ability to survive in an artificial environment.

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

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

In Ghana, cage fish farming primarily revolves around 2 species: Nile tilapia, *Oreochromis niloticus*, and African catfish, *Clarias gariepinus* (Plate 1-1). Nile tilapia accounts for almost 90% of species cultured. This species is relatively easy to culture, grows faster and has the ability to withstand and grow in harsh environmental conditions.

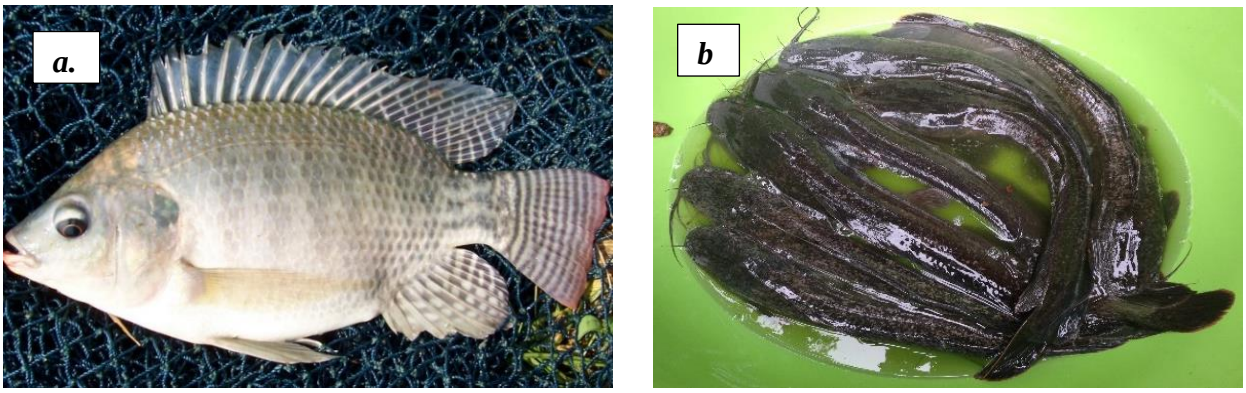

Plate 1-1: Different species for culture: a. Nile tilapia, b. African catfish

1.5 Permits for aquaculture operations

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

Before starting your operation, obtain an Environmental permit from the Environmental Protection Agency (EPA), water usage rights from the Water Resources Commission (WRC) and an Aquaculture permit from the Fisheries Commission (FC). Please note that to site a cage in the Volta Lake you will have to consult the Volta River Authority to approve your site before you start farming.

CHAPTER 2 CAGE SYSTEM

2.1 What is a cage system?

i. A cage is a system that confines the fish or shellfish in a mesh enclosure.
ii. It can be put on any body of flowing water (ponds, rivers, estuaries, open ocean, etc.), allowing for good water exchange while the fish are confined.
iii. The mesh retains the fish, making it easier to feed, observe and harvest them.
iv. It can be of any size, shape and form (Plate 2-1).

CIRCULAR CAGES

SQUARE CAGES MADE WITH PIPES

BAMBOO CAGES

WOODEN CAGE FRAMES

Plate 2-1: Different cage sizes and forms
(Source: Agyakwah et al., 2018)

2.2 Types of cage systems

i. ***Submerged:*** These cages are permanently kept under the water. They consist of a frame with slats for openings and are anchored to the substrate in flowing water.
ii. ***Floating:*** Floating cages are made from netting supported by a buoyant collar or a stable frame.
iii. ***Submersible:*** These cages are built with a rigid frame and because they are submersible, they can be moved up and down in the water column to take advantage of water conditions.
iv. ***Fixed cages:*** A fixed cage is essentially a net bag supported by posts that are anchored to the bottom of a river or lake. Their use is limited to shallow, protected water with soft substrates.

2.3 Advantages of cage system

i. Water flows freely in and out of the cage, flushing out waste and supplying much-needed oxygen
ii. There is greater protection from predators like birds, frogs, crocodiles, and other fish species
iii. It discourages reproduction (tilapia will not have any substrate to build their nests in)
iv. Harvesting is easier and less capital intensive as compared to other culture methods
v. It can be used to increase the productivity of different types of water resources, including lakes, reservoirs, ponds, strip pits, streams and rivers
vi. It can be stocked at higher densities and simplifies the observation and sampling of fish

2.4 Disadvantages of cage system

i. Depends entirely on a supply of formulated floating feed which increases production costs
ii. Water quality problems and diseases may occur as a result of other farmers' activities
iii. Strong winds can destroy cages
iv. Matured fish that are ready for market can easily be stolen
v. Predators can prey on your fish if there is an opening in the nets
vi. Clogging of cage net could cause mortality

vii. Fish may escape into the wild and cause gene pollution

CHAPTER 3 SITE SELECTION

3.1 SITING YOUR CAGE

The success of an aquaculture operation largely depends on the proper selection of the site to be developed into a fish farm or hatchery. Consider each of the factors below when selecting a site for your cage.

i. Water Depth: The water should be deep enough (at least 2 meters from the bottom of your cage net during the dry season or at low water levels).
ii. Water Quality: Water quality parameters such as temperature, dissolved oxygen, pH, turbidity, etc. have to be in ranges acceptable for the growth of the fish.
iii. Current: Your cage should be in a place where the flow of water is gentle (about 4cm/s). The water current keeps fish supplied with good oxygen, ensures permanent water exchange between the water body inside and outside of the cage and removes waste from the cage. In addition, the area should be protected from strong winds.
iv. Pollution: Your area should be free of pollution and environmental problems (including industrial and human waste). The water should not contain materials or substances that could poison the fish.
v. Traffic: Avoid setting your cage in water transport routes.
vi. Accessibility: The area should be free of physical obstacles, allowing for the easy supply of inputs and transportation of harvested products.

3.1.1 Economic and social factors

The following economic and social factors should be considered:

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

3.1.2 How to build your cage

A cage can be of any shape and size. It can be round, square or rectangular (Plate 2-1).

Cage components

A cage consists of the following main components:

A. Cage frames

i. Cages can be made of galvanized pipes, wooden frames, bamboo or other material that will not easily deteriorate in water.
ii. Cages can be of any size, depending on a farmer's specifications.
iii. The frame should be mechanically strong, resistant against corrosion, and easily repairable or replaceable.
iv. Special joints must be used for fixing the various frame elements together.

B. Netting and ropes

i. The netting has three major functions:
    a. Keeping the fish stock together;
    b. Protecting the stocks against harmful external influences;
    c. Allowing water to flow freely through the cage.

ii. The mesh size of the cage bag or production net is 1 inch. The mesh size of the protective netting is 2 inches, and the cover net can be made with either a 1- or 2-inch mesh size or ropes (6 mm, 10 mm, stroke 18, 21, nylon thread and braided twine).
iii. A quarter-inch net can be sewn and placed inside the production net to hold newly stocked fingerlings (weighing less than 2 grams) for nursing.
iv. A larger mesh size improves oxygen supply to the stocks and reduces fouling problems.
v. Avoid clogging and fouling the net by cleaning it regularly or replacing it as needed.

C. Floaters

i. The floats should suspend the cage structure (netting, frame, feeder, walkway, etc.) safely on the water surface.
ii. Examples of floaters include drums (rubber barrels), gallons and PVC pipes.

D. Anchors

The cage requires an anchor to hold it in place.

i. An anchorage can be made with concrete and placed in the water column to hold the cage firmly in place with 16 mm rope.

ii. A wooden platform can be laid on top of the cage to facilitate movement and farm operation (Plate 3-1).

Plate 3-1: Cage components
(Source: Agyakwah et al., 2018)

3.1.3 Installing your cage

i. Cage components (frames and floaters) should be fixed on land first, and then towed to the specified location on the water to be fixed (Plate 3-2).
ii. Secure your cage firmly in place by anchoring.

Plate 3-2: How to install your cage on the water
(Source: Agyakwah et al., 2018)

CHAPTER 4 TRANSPORTING FISH TO YOUR CAGE

Transport of fingerlings involves the movement of fish: within the same farm (on-farm movement), from one farm to another, from one country to another, or from one culture system to another (e.g., from pond to cage).

Certain principles and techniques must be used to ensure high survival rates, a clean environment and healthy fish.

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

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

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

i. Care must be taken when transporting fish to your cage
ii. Fish must be well conditioned before transport (*See text box*)
iii. Transport fish in the early morning or late evening (before sunrise or after sunset)
iv. Fish must be healthy and transported in clean waters
v. Fish can be transported in polybags or containers (Figure 4-1)
vi. Use ice to reduce water temperature during transportation

vii. Load your fish in a ratio of 1 kg of fish to 1 kg of water
viii. Allow enough oxygen for aeration
ix. If you carry your fish in poly bags, carry the bags in a box so that they will not break
x. Participate in the estimation of the fingerlings you want to buy

How to condition fish prior to transportation

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

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

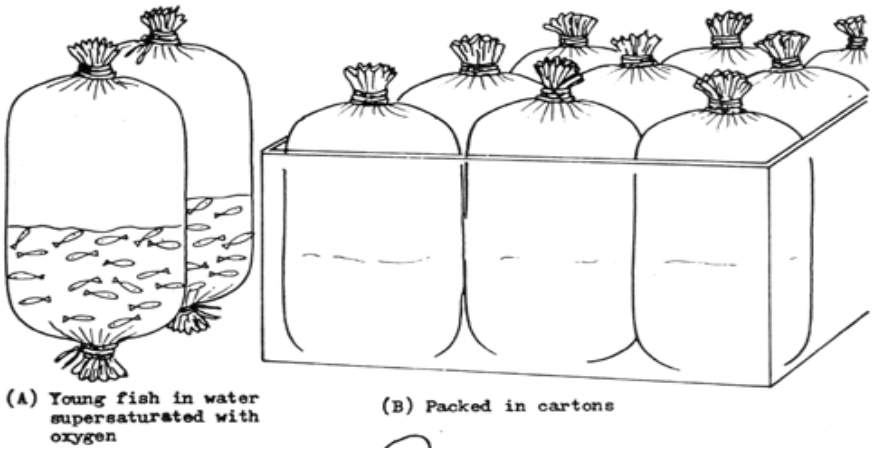

Figure 4-1: Packed fish ready for transport
(Source: FAO Training Series, 2010)

4.1 Stocking your cage

i. Obtain fingerlings from a certified nursery
ii. Fingerlings should be at least 10 grams in size
iii. Stock between 50 – 80 fingerlings per cubic meter, depending on management and market needs or demand (Table 4-1)
iv. Stock fish early in the morning if possible
v. Before releasing fish into your cage, make sure the temperature of the receiving waters is about the same as the temperature of the transport water (do this by allowing a gradual exchange of water between the two)

vi. Fish should be allowed to swim out freely from the bags/containers into their new environment (Plate 4-1)
vii. Be sure to take out any dead fish

Table 4-1: Size of cage and its appropriate stocking

Cage Size (LxBxH) (m)	Volume (m^3)	Effective production Volume (m^3)	Stocking Rate	Stocking Number
5x5x4	100	87.5	50-80	4,375-8,750
5x5x5	125	112.5	50-80	5,625-11,250
5x5x6	150	137.5	50-80	6,875 - 13750
6x6x6	216	198	50-80	9,900-19,800

NB: Survival of the fish and production outputs is subject to prevailing water quality conditions in the area and management options.

Plate 4-1: Stocking fingerlings in cages
(Source: Agyakwah et al., 2018)

CHAPTER 5 FEEDING YOUR FISH IN YOUR CAGE

5.1 Feeding your fish in your cage

i. Feeding your fish is an important component of the cage system since fish are restricted from searching for their own feed
ii. It is advisable to use a complete/formulated diet from a certified source
iii. Feed your fish 3 to 5 times a day – your fish will grow better if you feed them regularly
iv. Spread feed on the surface of your cage and remember to hang a mosquito net within the edges of your production net (feed guard) to prevent feed from moving out of your cage
v. Avoid underfeeding
vi. Your fish will eat more as they grow but be careful not to overfeed
vii. Feed your fish based on their body weight (quantity of feed per day = biomass x % body weight, where biomass = average weight x total no. of fish)
viii. The bigger your fish grow, the more food they will need
ix. Put in the food little by little so that you can watch the fish and see that they are eating

x. If you see that the fish eat all of their food quickly, give them a little more
xi. If fish aren't eating all of their food, give them a little less
xii. Uneaten food could indicate a problem (e.g., poor quality feed or deteriorated feed, low water temperature, sick fish)
xiii. Ensure the feed is appropriate for the size/age of the fish
xiv. For fingerlings and juvenile fish, use feeds with protein levels of 38% and above
xv. As fish age, feed them with grower feeds of crude protein below 38% (Table 5-1)
xvi. A feeding protocol guide on tilapia is shown in Table 5-2 to help you identify the right feeding rate

Recommended feed size for different development stages:

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

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

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

Table 5-2: Feeding protocol for tilapia based on optimal water quality and water temperature of 28 °C

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

Plate 5-1: Different feed sizes for feeding different stages of fish

5.1.1 Feed purchase, storage and handling

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

5.2 Fish sampling

i. You can monitor your fish growth and make adjustments for feed when you sample at regular time intervals (i.e., every month)
ii. To sample, remove fish from cages by partially lifting the cage bag and scooping fish out of the water with a dip net
iii. Weigh fish as quickly as possible and return them to the cage

Sampling is done for purpose of checking on the health, growth and general well-being of your fish.

i. It is always advisable to sample frequently (i.e., monthly)
ii. Sample early in the morning before feeding
iii. Scoop a sample of fish stock (minimum 30 pieces), place it on a scale and divide the displayed weight by the total number of fish to get the average weight of the fish (Plate 5-2)
iv. The change in weight from the previous sample will tell you how your fish are growing
v. Remember fish must always be in water to minimize handling stress
vi. Wear gloves to handle fish
vii. Isolate fish that show signs of sickness and report immediately to an Extension Officer
viii. Do not sample during extreme stress or poor/bad water quality
ix. When you see a different fish in your sample other than your tilapia, you must discard it
x. Regularly inspect the cage nets (production, protective, etc.) to correct any damage

Plate 5-2: Processes of fish sampling
(Source: Agyakwah et al., 2018)

CHAPTER 6 WATER QUALITY MANAGEMENT

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

6.1 How to maintain good water in your cage

i. Remove any dead fish as soon as you spot them
ii. Watch out for signs of bad water quality
When water quality is bad, reduce feeding

6.2 Signs and effects of poor water quality

i. Changes in water color (e.g., too greenish or brownish)
ii. Foul smell (water smells bad)
iii. Fish gasp for air at surface
iv. Increase in turbidity (water looks murky)
v. Fish don't respond to feeding
vi. Slow growth of fish
vii. Changes in swimming patterns
viii. Dead fish (Plate 6-1)

6.2.1 Causes of bad water quality

i. Use of poor quality feed
ii. Overfeeding

iii. Overstocking
iv. Decomposition of vegetation
v. Polluted water source (agro-chemicals, pesticides, etc.)
vi. Water upturn
vii. Dead fish in the cage

Plate 6-1: A sign of bad water quality
(Source: Agyakwah et al., 2018)

6.2.2 How to manage water quality

i. Regular monitoring of key parameters
ii. Aerate when necessary
iii. Remove all dead fish from the cage as soon as you observe them
iv. Keep to appropriate stocking density
v. Ensure appropriate feeding plan – do not overfeed
vi. Regular cleaning of cage nets and structures
vii. Reduce feeding when water quality is bad

6.2.3 Effects of poor water quality

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

6.2.4 Benefits of good water quality management

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

6.2.5 Important water quality parameters and their acceptable ranges

i. pH (6.5 – 8.5)
ii. Dissolved Oxygen (> 3 mg/l)
iii. Temperature (25 – 30 ºC)

iv. Ammonia (< 0.03 mg/l)
v. Nitrite (< 0.6 mg/l)
vi. Turbidity (< 75 NTU)

6.3 Caring for your fish

i. Monitor your fish regularly
ii. Fish will show signs if conditions are not favorable (e.g., erratic swimming, loss of appetite, unusual gasping for air, mortalities)
iii. If your fish show these signs, check the water quality and try improving it if necessary
iv. If condition remains unchanged, stop feeding immediately for a day or two, and seek help or advise from a fishery officer or an Extension Officer
v. When you begin to feed them again, first give them small amounts of food and then slowly increase the amount
vi. When your fish begin to eat as before, you will know that they are well again
vii. Remove any dead fish as soon as you spot them

6.3.1 Cleaning and maintaining your cage

i. The meshes in a cage get clogged with dirt, debris, algae and other matter that may be found in the water column.
ii. This prevents the free flow of water, nutrients and dissolved oxygen into and out of the cage.
iii. Effective cleaning of the cage must be carried out regularly for optimum performance of the fish and cage.
iv. The netting material should be cleaned with a brush or soft broom, if possible (Figure 6-1).
v. Check the cage routinely to make sure there are no holes or gaps in the netting.
vi. Gaps in the netting should be mended immediately with mending twine.
vii. You also need to inspect your anchorage intermittently to make sure your cages are firmly in position.

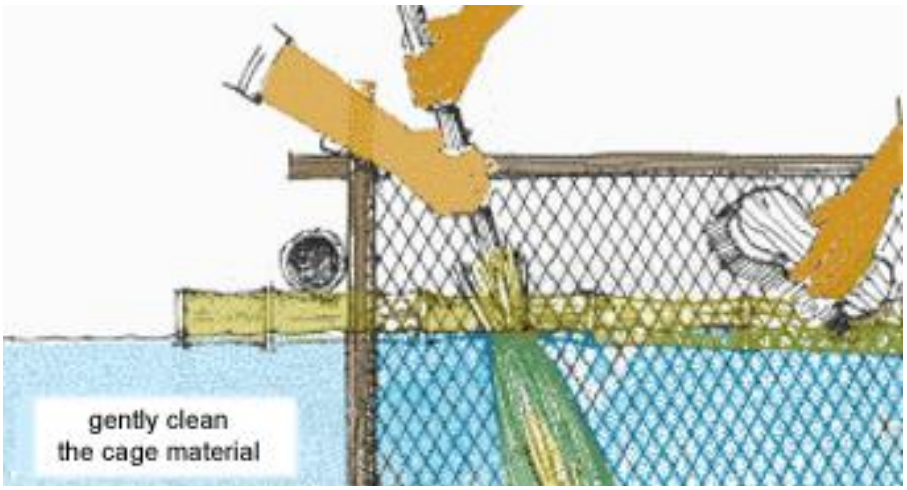

Figure 6-1: Cleaning cage net with a brush
(Source: FAO Training Series, 2010)

CHAPTER 7 BIOSECURITY MEASURES AND FISH HEALTH MANAGEMENT

7.1 Choice of farm location

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

7.2 Design of farms

i. Know the planned land-use activities of the area
ii. Measures to be adopted on farm
   a. Ensure that all inputs and supplies (e.g., animals, feed, drugs and chemicals, etc.) coming into farm are from a certified source
   b. Incoming water should be safe, adequate and good quality
   c. Vehicles, equipment and visitors must have designated points with clear signage
   d. Regularly disinfect all equipment used to handle fish (Table 7-1)
   e. Maintain and improve standard of farm sanitation and hygiene (farm, equipment and staff/visitors) (Table 7-2)
   f. Dead animals and trash fish should be properly disposed of at designated sites
   g. Moribund animals should be kept in a safe location and properly disposed of at designated sites once dead
   h. Reduce stress levels in animals by avoiding overcrowding, overfeeding, underfeeding, excessive handling, etc.

7.3 Stress in fish

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

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

Table 7-1: Disinfection of equipment

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

Table 7-2: Disinfection of farm and production materials

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

(Source: FAO Training Series, 2010)

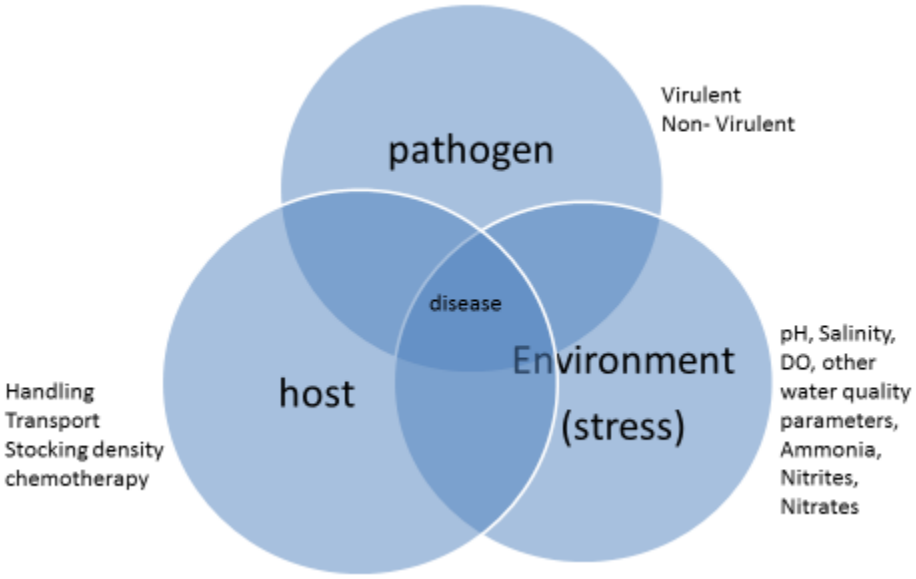

Figure 7-1: Host, pathogen and environment relationship

7.3.1 What are the causes of stress on fish?

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

7.3.2 Common signs of diseases in fish (Plate 7-1)

i. Erratic swimming
ii. Gulping for air
iii. Crowding at inlets and outlets
iv. Rubbing body against cage walls or protruding objects
v. Reduced or no feeding
vi. Swollen/protruded abdomen (stomach)
vii. Pop/blind eye
viii. Wounds

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

7.3.3 Sampling for laboratory diagnosis

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

7.3.3 Controlling the spread of fish diseases

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

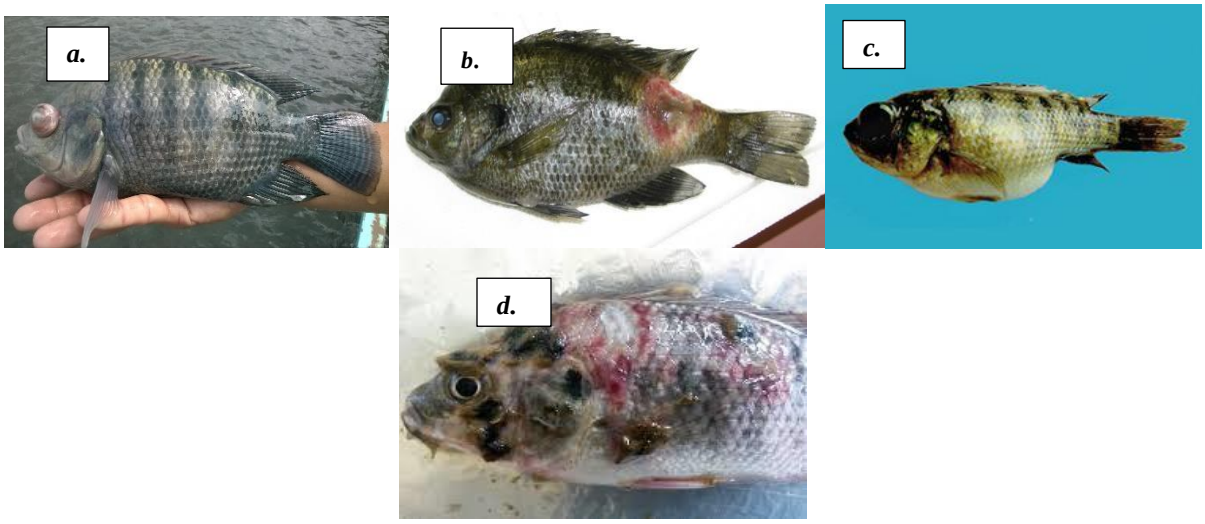

Plate 7-1: Some diseases of tilapia: a. pop eye, b. ulcerations on skin, c. swollen abdomen, d. molds and ulceration on skin

Plate 7-2: Mortalities being buried

CHAPTER 8 HARVESTING AND MARKETING YOUR FISH

8.1 Considerations before harvesting fish for market

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

8.2 Harvesting your fish

i. When fish have reached a desired size or market demand is sufficient, it's time to harvest
ii. Harvesting is done based on your marketing plan
iii. Before harvest and sales, fish should be subjected to a health inspection
iv. You can conduct partial or complete harvesting depending on the market demand
v. To harvest your fish, lift your net so that the fish are concentrated towards one end, and then scoop them with a hand net into a container (Plate 8-1)
vi. After you have harvested your fish, clean and repair your cage as quickly as you can so that you can begin another production cycle

Plate 8-1: Processes involved in harvesting of fish in cages
(Source: Agyakwah et al., 2018)

8.3 Advantages and disadvantages of partial harvesting

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

8.4 Effects of total harvesting

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

8.5 How to maintain the freshness of your fish

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

8.6 Marketing plan

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

i. Where can you sell your table fish?

ii. Which kind of fish do the consumers prefer?
iii. To whom to sell your fish?
iv. How to sell your fish?
v. When to sell your fish?
vi. At which price to sell your fish?

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

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

CHAPTER 9 GOOD FARM MANAGEMENT PRACTICES

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

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

9.1 Recordkeeping

9.1.1 How to keep records on your farm

i. It is always advisable to keep proper records of your farming operations (Table 9-1).
ii. A lack of records or poor recordkeeping in any venture is likely to result in bad decision making due to a lack of business insight
iii. Records that are properly designed and stored and easily accessible are the best sources of information about your business – use them to drive your decisions
iv. Proper farm records are needed to improve the efficiency of the farm's operations and preserve the memory of the farm for future reference
v. Some important fish farming records include:
    a. Summary Cost of Production,
        - Cost of adjoining land
        - Cage construction
        - Permits (Water Resources Commission, Fisheries Commission, Environmental Protection Agency, Local Government (District Assembly), Volta River Authority)
        - Inventory of farm assets
        - Source and cost of fingerlings
        - Cost of feeds
    b. Total number of cages,
    c. Individual cage identity/dimensions,
    d. Stocking densities/numbers
    e. Dates of stocking and harvesting,
    f. Size/quantity of fish at stocking and harvesting,
    g. Mortalities,

h. Quantities and cost of inputs used,
i. Cage productions in quantities and values,
j. Daily occurrences,
k. Salaries of farm workers,
l. Disease situations/outbreaks
m. Repairs and maintenance
n. Visitors/Extension Officer

Table 9-1: Recommended formats for recordkeeping

Field Inputs Log A record of the materials you use for each field.			
Farm Name or Unit:	Field ID:	Acres:	Crop: Year:
Seeds / Transplants			
Date	**Crop / Variety Planted / Transplanted**	**Seeding Rate / Transplant Spacing**	
Fertilizers / Pest Control			
Date	**Material Applied / Brand or Source**	**Rate / Amount**	**Notes**

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

Farm Name/Owner's Name: _____

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

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

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

Farm Name/Owner's Name: ________________________________

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

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

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

Farm Name/Owner's Name: ____

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

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

9.1.2 Economic analysis

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

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

or

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

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

CHAPTER 10 BUSINESS MANAGEMENT AND PLANNING

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

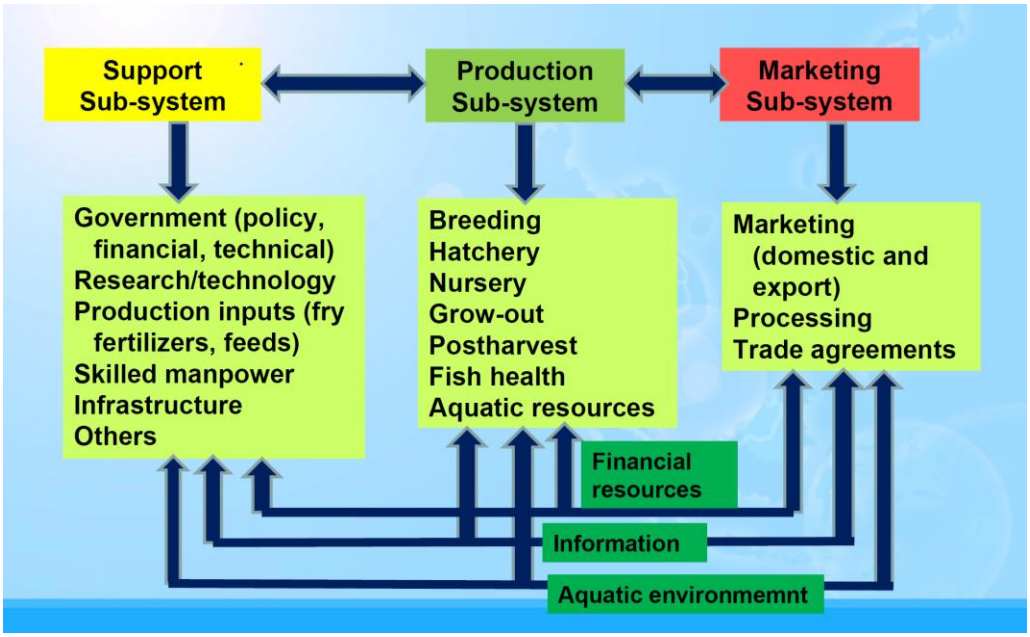

Figure 10-1: Aquaculture industry system showing relationships among the aquatic environment, production, marketing and support systems
(Source: JICA-SEAFDEC 2019 Aquaculture Training Handout)

10.1 Factors affecting profitability of aquaculture enterprise

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

10.2 Enterprise management principles/rules

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

10.3 Marketing strategies

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

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

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

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

i. Identify your key markets
ii. You can manipulate any of the four 4 Ps in an optimal manner to satisfy customers in target market

10.4 Market study

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

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

10.5 Dealing with risks and uncertainties in aquaculture

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

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

10.5.1 Strategies to reduce risks and uncertainties:

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

REFERENCES

Agyakwah, S.K; Anani, F; Mensah, E.T.D and Agbeko, E. 2018. Hands-on training hand-out on small scale cage fish farming. CSIR-WRI, CSIR/WRI/MA/SKA/2018/2, 47 pp.

FAO. (2010) Simple Methods for Aquaculture: Manuals from the FAO Training Series. http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/General/t0581e/Index.htm

Fisheries Act, 2002 (Act No. 625 of 2002). http://extwprlegs1.fao.org/docs/pdf/gha34737.pdf

Fisheries Regulations, 2010 (L.I. 1968). http://extwprlegs1.fao.org/docs/pdf/gha151991.pdf

GLOSSARY

Aeration: The mechanical mixing of air and water
Algae: they are primary producers, i.e. they are the start of the food chain
Ammonia: a colorless gas with a characteristic pungent smell, which dissolves in water to give a strongly alkaline solution
Anchorage: a place where something, say cage is fastened firmly
Clog: block or become blocked with an accumulation of thick, wet matter
Culture: to grow or rear
Debris: scattered pieces of rubbish or remains
Decomposition: the state or process of rotting; decay.
Disinfect: clean (something), especially with a chemical, in order to destroy bacteria
Dissolved oxygen: is a measure of how much oxygen is dissolved in the water
Erratic swimming: swimming in a way that is not regular, certain, or expected
Excretion: the process of eliminating or expelling waste matter.
Filleting: to remove the bones from the fish
Fingerling: Related to any fish from advanced fry to about the size of a human finger
Fouling: make foul or dirty; pollute.
Gulping: breathe or swallow with difficulty
Gutting: remove the intestines and other internal organs from (a fish or other animal)

Juveniles: young fish
Hapa: it refers to a small, fine-mesh net enclosure set up in a shallow pond to raise fish larvae
Infectious pathogen: is a biological agent that causes disease or illness to its host
Loss of appetite: means you do not have the same desire to eat as you used to
Mesh size: The size of holes in fishing net
Microorganisms: An organism that can be seen only through a microscope and capable of causing infection
Moribund: being in the state of dying
Mortality: the state of being subject to death.
Mold: is a fungus that grows in the form of multicellular filaments called hyphae
Nursery: a pond designated for nursing young fish
pH: a figure expressing the acidity or alkalinity of a solution
Polluted: contaminated with harmful or poisonous substances
Predators: an animal that naturally preys on others.
Production cycle: is comprised of all activities related to the conversion of raw materials into finished goods
Stress: to subject to pressure or tension.
Temperature: the degree or intensity of heat present in a substance or object
Turbidity: the quality of being cloudy, opaque, or thick with suspended matter.
Waterproof: not allowing water to pass through
Water quality: refers to the chemical, physical and biological characteristics of water