Extension Manual on Mono-sex Tilapia Production and Management

First Edition

TAAT Aquaculture Compact

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Guide for Users

This material has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies to tilapia breeders to ensure high quality seed production and profitable ventures. The contents are in simple terms for easy understanding. Learning objectives, activities, materials and facilitation methods are well highlighted. Other key component parts of this module are instruments for pre-and post-course evaluation, output evaluation and outcome evaluation, and feedback mechanism. These are provided for periodic improvement of the manual. The learning objectives accomplishment is based on activities properly scheduled and executed. Learning materials are packaged for different hatchery and nursery staff to acquaint them with necessary knowledge and skills for successful mono-sex tilapia production.

The manual is only an instruction device. Therefore, trainer should run the session with necessary adjustment considering the knowledge and experience of trainees. Training methodologies and technicality of each session are described in detail. These have been carefully planned to ensure active participation of the trainees in the training. Sticking to the methodologies will ensure active participation of trainees and expected outcomes of the session will be achieved. Training sessions are arranged in sequence. Necessary information will be discussed within fixed time in each session. If necessary, the trainer, based on his/her own experience, can change or modify the session keeping the main topic as it is. However, timely starting and ending of sessions is good for both trainers and trainees. Assessing the success of the training program is important for both trainers and trainees. Therefore, learning of the trainees needs to be evaluated during and after the training. Instruments for evaluation assist in assessing how well-set targets have been met while feedback enables assessment of overall progress leading to achievement of overall objectives.

Target Audience

These are mainly tilapia breeders consisting of women (30%), men (70%) and youths inclusive according to the level of involvement along the aquaculture value chain. Any of these categories within the age bracket of 15-60 years are prospective learners.

One para about FISH CRP and BP resource development. (Florine can add it and adjust for tilapia production).

Background

Technologies for Africa Agricultural Transformation (TAAT) is a framework developed by the Africa Development Bank as part of its current efforts to foster the development of Agriculture on the continent. It aims to enhance the use of proven agricultural technologies among the stakeholders to foster needed change through farm level productivity and value chain development. Aquaculture is one of the nine commodity compacts with pre-screened technologies that have potentials for increased yield and benefits for up-scaling in 12 countries in Africa. These are: Benin, Burundi, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Ghana, Kenya, Malawi, Nigeria, Tanzania, Togo and Zambia. The TAAT Aquaculture Compact led by WorldFish has been training aquaculture Subject Matter Specialists (SMSs) and youth agripreneurs as facilitators under the capacity development and technology outreach.

Specific objectives of the Aquaculture Compact are – (i) Creating an enabling environment for aquaculture technology adoption by the value chain actors; (ii) Facilitate effective delivery of technologies to fish farmers and other actors along the aquaculture value chain; (iii) Increase aquaculture production and productivity through the identification and dissemination of quality tilapia and catfish seed, production of low cost fish feed and value addition.

Tilapia, *Oreochromis niloticus* is a good candidate species for culture to boost fish production for both domestic and global markets. In Africa this will contribute to fish nutrition and security. However, a major problem that has been an obstacle in realizing this is earlier sexual maturity and prolific nature of tilapia resulting to stunted growth, which is unattractive to market. The essence of this extension manual is to expose extension workers to Better Management Practice (BMP) in mono-sex tilapia production and facilitation techniques in disseminating the technology. This will enable them disseminate skills gained to fish breeders in their respective areas for increased high-quality fingerlings production for fish farmers' uptake.

Rationale for the Training Manual

The TAAT Aquaculture Compact has noted the following challenges by fish breeders in production of tilapia in Africa. These include lack of access to quality fish seeds; limited

knowledge to implement tilapia breeding in BMPs; high mortality rate of fry and fingerlings. Material has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies to tilapia breeders for fast growing and healthy fingerlings to ensure profitable ventures.

Development Objectives

The development objectives of this material are:

i. Enhanced productivity of Tilapia
ii. Increased farmers' income and,
iii. Food (fish) security and improved nutrition.

Learning Objectives: *change in learners' behavior (knowledge, skills, and attitude)*

At the end of this training, participants should:

i. Have enhanced knowledge on broodstock management and egg incubation.
ii. Acquire skills on feed preparation for tilapia sex reversal and production of mono-sex fingerlings.
iii. Acquire entrepreneurial skills in business plan development for sustainable venture
iv. Acquire skills on how to share knowledge gained with other tilapia seed breeders in their respective areas for increased tilapia production.

Pre-Evaluation (with Feedback):

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide and this could be open or close-ended.

Ten (10) simple questions should be raised on each of Modules 1-4

MODULE 1

1.0. INTRODUCTION

1ai. Learning Outcomes/Learning Activity Bundle

For each learning outcome, prepare prompting questions for participants to share their experience about the intended contents (experiential learning) at the end of the module.

1aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning.

1a. ii. Pre-Evaluation with Feedback

Five (5) questions should be prepared based on content of Module 1.

1. The following are advantages of culturing tilapia except:

(a) Mono-sex tilapia is superior with respect to growth and yield per unit area and has great value and demand.

(b) They are often densely stocked; which saves space and can be cultured at high stocking density especially in cages

(c) Tilapia is less stress tolerant compared with some indigenous cultured species like catfish

(d) They possess the ability to feed on natural foods in the pond and equally thrive well on supplementary feeds.

2. The following are disadvantages of culturing tilapia except:

(a) The growth rate of individual fish is usually affected due to high stocking density.

(b) They reach market size faster than mixed sex tilapia at harvest if properly fed.

(c) It is challenging and difficult to maintain good water quality.

(d) Densely stocked systems are prone to ill-health.

3. Tilapia fishes are very prolific species. True or false?
4. Why is Tilapia, referred to as an 'Aquatic Chicken'?
5. Why is mono-sex tilapia culture preferable to mixed sex culture?

1.1: Origin of Tilapia - Why Tilapia, the 'Aquatic Chicken'?

Tilapia is one of the world's most important farmed fish after carps. They are good fish for warm water aquaculture. The common name 'Tilapia' is broadly applied to a group of cichlid fish species that originated from Africa, the Middle East and the Mediterranean regions. Tilapias are some of the oldest fishes to be cultured. Production of tilapia can be extensive (in earthen ponds) or intensive (in cages and tanks). Tilapia can be cultured in either fresh or salt water in tropical and subtropical climates.

The most commonly cultured is the Nile Tilapia, *Oreochromis niloticus* and it is the most dominant worldwide. Tilapia has mild flavor white flesh, tolerates a wide range of environmental conditions and is a suitable polyculture candidate with carps and catfish.

It is usually called aquatic chicken because it breeds easily and can be mass produced. A perfect factory fish since it has no bones in muscles, thereby making it very suitable for filleting and feeding children. Tilapia eats pellets made from plant sources (largely of corn and soy) which results in rapid weight gain. They easily convert diets that resemble cheap chicken feed into low-cost source of animal protein. Tilapia like chicken can be farmed in simple backyard systems or high-tech largescale or intensive systems.

In 1994, the Genetically Improved Farmed Tilapia (GIFT) strain was introduced by ICLARM (present WorldFish) in order to improve tilapia productivity and marketing. The GIFT strain grows bigger in size making it more acceptable to consumers. Its international market size ranges from 450-550g. The culture of GIFT - *Oreochromis niloticus* is widely gaining popularity in developing countries. It is now highly popular at farmers' level in Africa. Recently many tilapia hatcheries have been established in African countries with production of the fry and fingerlings of mono-sex tilapia.

1.2: The Rationale for Mono-Sex Tilapia Production.

Tilapia fishes are very prolific species and this prevents optimum growth of the fish or low conversion of feed to flesh. In the female fish especially, metabolic energy is directed toward reproduction. Therefore, male tilapia fish are economically attractive because they have faster growth rate in which metabolic energy is channeled towards growth. It is therefore advisable to adopt the mono-sex culture. Mono-sex tilapia (all-male production) can be obtained by manual sexing, use of hormones, genetically improved farmed tilapia, YY male technology, or hybrids.

Although production of mixed sex is technically easy, the yield is always very low with small harvest weight and mixed sizes at harvest. On the contrary, mono-sex technology is technical and easier to produce all male tilapia fingerlings close to 98% in any production cycle. The use of hapa technology in fish seed production allow for higher survival rate of mass production of tilapia.

1.3. Advantages of Mono-sex Tilapia and Disadvantages of Mixed-sex Tilapia

Advantages of Mono-sex Tilapia:

- Mono-sex tilapia is superior with respect to growth and yield per unit area and has great value and demand.
- They are often densely stocked. This saves space and can be cultured at high stocking density especially in cages.
- They possess the ability to feed on natural foods in the pond and equally thrive well on supplementary feeds.
- Three crops are possible in perennial ponds
- Can be profitably cultured in seasonal ponds and small ditches, canals close to the homesteads
- They have high diseases resistance ability and can survive in adverse weather with a wide range of temperature (12-40^{o}c) and tolerate saline water (salinity 12-15 ppt.)
- Reach market size faster with uniform sizes at harvest if properly fed.

  Disadvantages of Mixed-sex Tilapia:
- The growth rate of individual fish is slower due to high stocking density.
- It is challenging and difficult to maintain good water quality.
- Densely stocked systems are prone to ill-health.
- Tilapia is less stress tolerant compared with some indigenous cultured species like catfish.
- The use of hormone on human health has a perceived negative notion.

1b.i. Leaning Activity:

Learning activity will be prepared that leads to discussion, remembering, memorizing and action on Module 1

1b. ii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. *Lecture with audio-visuals*

ii. *Brainstorming on issues raise*

iii. *Role plays on key issues*

iv. *Group discussion and feed backs in plenary*

1b.iii. Learning Materials

Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content. Sequential narration of module will be accomplished in simple non-technical form.

1b. iv. Output Evaluation/with Feedback

Prepare evaluation questions based on the content/s you covered (Could be open-ended or close-ended questions). Then prepare answers for learners to check their performance.

1. Which of the following is a disadvantage of culturing tilapia?

(a) Mono-sex tilapia is superior with respect to growth and yield per unit area and has great value and demand.

(b) They are often densely stocked; which saves space and can be cultured at high stocking density especially in cages

(c) Three crops are possible in perennial ponds

(d) Perceived negative notion of hormone on human health.

2. The following are disadvantages of culturing tilapia except:

(a) The growth rate of individual fish is usually affected by high stocking density.

(b) Tilapia can survive in adverse weather with a wide range of temperature (12-40^{o}c) and tolerate saline water (salinity 12-15 ppt.)

(c) It is challenging and difficult to maintain good water quality.

(d) Densely stocked systems are prone to ill-health.

3. Which of the following is not a method of obtaining mono-sex tilapia?

(a) Manual sexing (b) hormones (c) YY male technology (d) laceration

4. Hapa technology allows:

(a) Management flexibility as is seen in the usage of collapsible/foldable tank.

(b) Fast growth

(c) Regular change of water

(d) For killing of female tilapia leaving only the male fish

5. Male tilapia is preferred to females because:

(a) They eat faster than the female tilapia which eat tiny portion

(b) They are immune to infections while the female tilapia has no immunity against infections

(c) Better growth of male tilapia fish; metabolic energy is channeled to growth.

(d) Tilapia fishes are very prolific species. True or false?

6. Why is Tilapia, referred to as an 'Aquatic Chicken'?
7. Why is mono-sex tilapia culture preferable to mixed sex culture?
8. Although mixed sex is technically easy, the yield is always very low with small harvest weight and mixed size at harvest. What is the reason for that?
9. Is tilapia suitable for polyculture?
10. Tilapia can only be grown in countries with warm weather. Is the statement correct or wrong?

MODULE 2

SITE SELECTION, POND CONSTRUCTION AND MANAGEMENT

2a.i. Learning Outcomes/Learning Activity Bundle

For each learning outcome, prepare prompting questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module.

2a. ii. Pre-Evaluation with Feedback

The purpose of pre-evaluation questions are to assess learner's behavior (knowledge, skills, and attitude) before they start learning.

1. Which o\f the following is not a factor to be considered when siting for pond construction?

   (a) Topography (b) Soil quality (c) Availability of water (d) all of the above

2. What are the disadvantages of having large ponds?
3. What are advantages of having small sized ponds?
4. What are the disadvantages of siting ponds in places prone to flooding?
5. What is the need for security plans in a fish farm?

2.1 Better Management Practices in Site Selection

The most important factors in site selection are:

- Local topography:
  - Topography goes a long way in determining the type and size.

- Ensure the site is where water drainage is possible by gravity.
- Get a site with the least earth movement.

- Availability of water:
  - Find out about other users (current or potential) of land, water and other natural resources which may impact directly or indirectly the water quality; such as an existing factory or a planned development of quarry site.
  - The availability of good quality water is important to the success of the farm
- Soil quality:
  - Do not use a site that has gravel bed, deeply rooted stumps, rock outcrops, limestone etc.
  - Clayey loam, sandy clay and silty clay loam are preferred.
  - Do not site pond in a place that has sandy soil due to porosity and a place with termite mounds or termite activity which may create leaks in the pond.

Other important factors are:

- Size of market: the enterprise has a higher chance to be successful where there is a larger market.
- Security: poachers are some of the main problems of aquaculture and are capable of ruining the business.
- Vegetation cover: heavy canopy trees and dense vegetation will require more cost of clearing.
- Accessibility: The site should be accessible by road to buy inputs and sell products.
- Nearness to home: It is important that the ponds are close to the fish farmer's home for ease of management, monitoring and security against poaching.
- Nearness to market: the value attracted by fish depends on freshness. Fresh fish is therefore sold as soon as possible with the least transportation cost.

Other BMPs on site selection

- Do not make a pond on a spring or water source. Rather, use a spring as inlet water source or the water can be collected in a reservoir then channeled into ponds.
- It should be ensured that the site is protected from flooding so as not to incur losses.

2.2. The BMPs on Pond Construction

- Size and shape of pond depends on the purpose and intensity of production, and construction cost. Rectangular ponds are the most common shapes of ponds and this is

because it is the most practical to construct and manage, however, the bigger the pond size, the more flexible it can be with shape. Pond size may vary widely from as small as 50 m^2 to 1 ha.

- Pond water depth should be about 0.8 m at the shallow end and increase gradually to about 1.2 m at the deep end, with 0.3–0.5 m of freeboard (Plate 1).

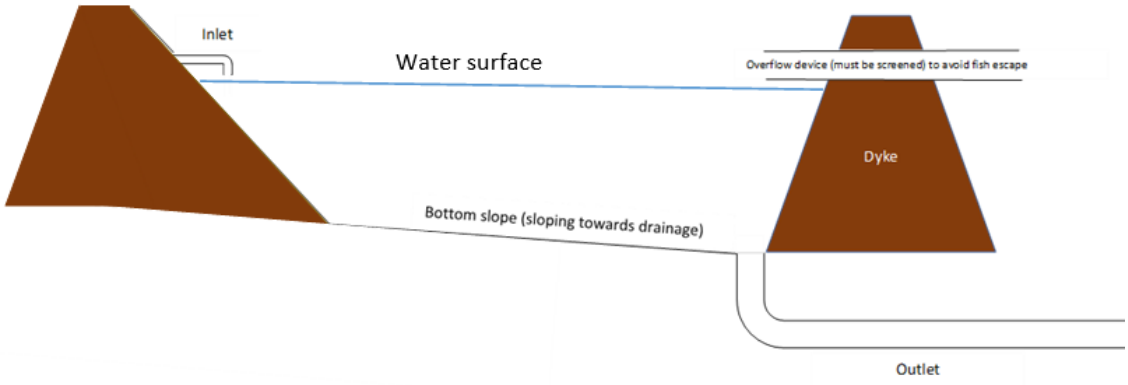

Plate 1: Profile and features of a well-constructed Pond

- The pond dike should be above ground level so that it can prevent flood water from running into the water and floodwater cannot enter the pond. Ensure they are wide enough between ponds to avoid the risk of breakage or dyke failure and to provide workspace. It can vary in width depending on what will be going over it such as humans, vehicles, machineries. At least a dyke should be up to 1 m wide.
- The inner and outer sides of the dyke should be sloped between 1.5:1.0 to 2.0:1.0 to prevent dyke from collapsing or dyke failure due to water reaction especially on the inner side of the dyke (Plate 2).

Plate 2: Profile of a sharp-sloped dyke and a gentle-sloped dyke

- The soil used for the dyke should not contain large amounts of rocks, sand, wood or plants in order to avoid leaks.
- Inlet and outlet canals should be strictly separated; no water flow should be allowed from one pond to another to avoid management related issues especially during a disease outbreak.
- Inlet water should be treated in a reservoir or using filtration, if need be. The flow of water into each pond must have individual valves for control (Plate 3). Inlet water should be screened to keep out wild fish, twigs, leaves and other trash.

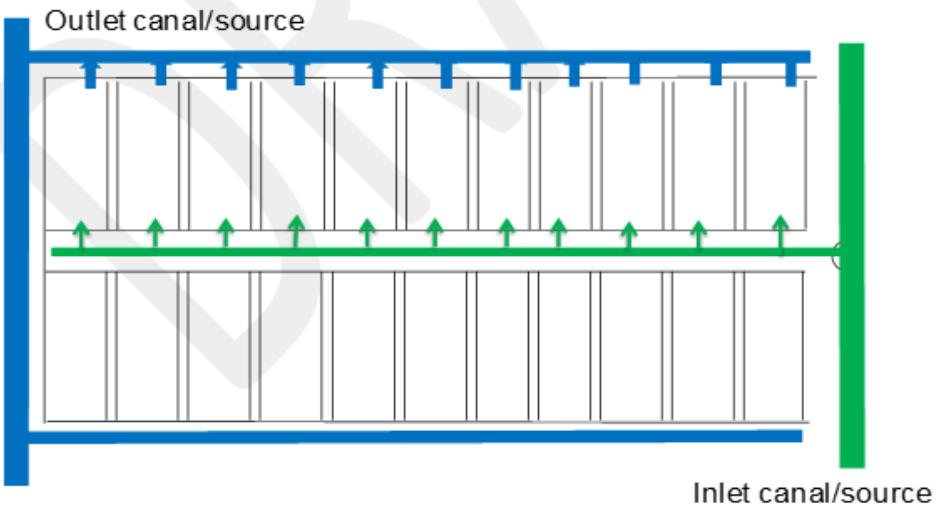

Plate 3: Fish Farm Layout with Inlet and Outlet Structures

- The outlet should be at the deepest end of the pond so that all the water can be drained out of the pond by gravity.
- The inlet and overflow pipes should be at least 20 cm above the water surface to prevent fish escape.
- Wastewater should go through a sedimentation pond or canal to avoid pollution of the natural environment. The outlet should be screened to avoid the release of dead fish or other waste going into the surrounding environment.
- Dig a small ditch to aid harvesting. It should be made in the lowest area of the pond bottom toward the drain outlet with a width of 2m (Plate 4).

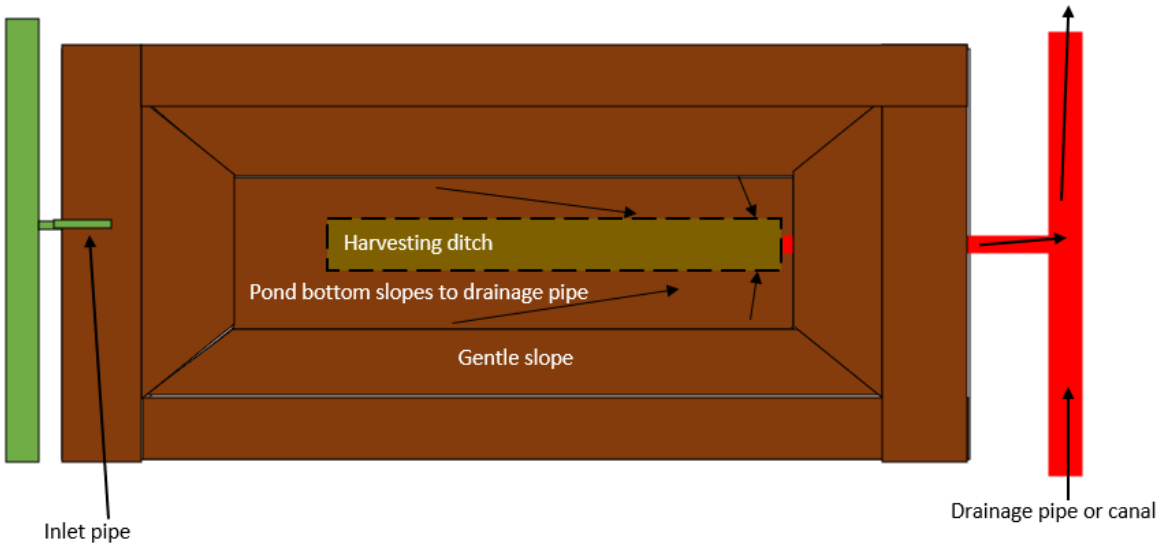

Plate 4: pond layout with inlet, outlet and harvesting ditch structures

2.3. The BMPs on Pond Maintenance

- When a pond has been drained, it should be left to dry until the base cracks. Agricultural lime should also be applied to increase soil pH. This should be done for a minimum of 10 days before the inception of another cycle or batch. This helps to improve soil properties and dispose of some organic wastes, kill small and harmful organisms. Quick lime can be used as follows: 2000 kg/hectare for highly acidic soil or pond, 1200 kg/ hectare for acidic soil or pond, 1000 kg/hectare for slightly acidic soil or pond, 400 kg/hectare for neutral soil or pond. formalin or chlorine can also be used.

- Regularly clean the mesh on the overflow pipe in undrainable ponds where water flows continuously to avoid blockage.
- Always maintain grasses on the dyke. Check dykes for holes and fix them. Maintain the ditch by lifting mud onto dikes. Inlet and outlet canals should also be checked and maintain their depth to ensure water flow.

2b.i. Leaning Activity:

Learning activity will be prepared that leads to discussion, remembering, memorizing and action on Module 2.

2b. ii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. *Lecture with audio-visuals*

ii. *Brainstorming on issues raise*

iii. *Role plays on key issues*

iv. *Group discussion and feed backs in plenary*

2b.iii. Learning Materials

Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content. Sequential narration of module will be accomplished in simple non-technical form.

2b. iv. Output Evaluation/with Feedback

Prepare evaluation questions based on the content/s you covered (Could be open-ended or close-ended questions). Then prepare answers for learners to check their performance.

1. What would be your advice to a colleague who acquired a land he plans to use for fish farming? The following are his findings about the land:

I. Availability of all year-round river water.

II. Pesticide factory upstream within a short distance.

III. Nearness to a large market.

2. What would be the effect if the outlet of a pond is not at the deepest end of the pond?
3. Why should wastewater go through a sedimentation pond or canal before release into the natural environment?
4. What is the use of an overflow pipe in a pond?
5. What can possibly happen if the soil used for the dyke contains large amounts of rocks, sand, wood or plants?
6. A pond without inner or outside slope tend to be stronger. True or false? Give a reason for your answer.
7. What is the importance of liming a pond before starting a new batch of production?
8. What are the disadvantages of having small ponds?
9. What are the advantages of having large ponds?
10. Which of the following is not a part of pond?

(a) Outlet (b) Dyke (c) Slope (d) Topography

MODULE 3

REPRODUCTION AND INCUBATION

3a.i. Learning Outcomes/Learning Activity Bundle

For each learning outcome, prepare prompting questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module.

3a. ii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning.

Five (5) questions should be prepared based on content of Module 3.

Pre-Evaluation with Feedback

1. stocking ratio is commonly
   (a) 2-3 females to 1 male (b) 20 females to 1 male (c) 1 females-10 males (d) none of the above
2. The optimum pH for tilapia is

(a) 6.5 - 7.5 (b) 1-2 (c) <4.5 (d) >8.5

3. Which of the broodstock will you choose if you were involved in a broodstock selection process?

(a) Presence of wounds

(b) Absence of body wound and parasites

(c) Presence of deformation of body and or fin

(d) All of the above

4. The number of eggs in one batch ranges from
   (a) 100-2,000 (b) 50-100 (c) 600,000-1,000,000 (d) 340,000-450,000
5. What is the age of tilapia fish at first maturity?

3.1 Reproduction in Tilapia - Sexual Dimorphism

In tilapia production, male tilapia is the most preferred for grow-out. This is because they are more efficient with time and energy, hence they grow bigger and are more profitable. Meanwhile, the female tends to waste energy and time, because of reproduction. Sexual dimorphism is the condition where two sexes of the same species exhibit different

characteristics apart from the differences in their sexual organs. Such differences may be in colour, shape and size which makes male distinct from females.

Generally, female tilapia fish can be distinguished by looking at the genital papillae behind the anus, it has a more rounded shape with triangular indentation in the center (Plate 5). In the male the genital papilla is tapered in shape while the female has a separate opening for eggs and urine (urinary opening and oviduct). Female has three apertures: anus, urinary and genital. The urinogenital aperture is smaller. Male has the same opening for sperm and urine (urogenital opening), which are two apertures on ventral side of belly. i.e. anus and urinogenital aperture. The latter is smaller.

In nature males are bigger and grow bigger under culture conditions. Age at first maturity is 4-5months and mature fish spawn 6-12 times a year. Males are polygamous; stocking density is commonly 2-3 females to 1 male. The number of eggs in one batch ranges from 100-2,000 depending on the size of female.

Plate 5: Male and Female Tilapia

3.2 BMPs in Broodstock Selection and Care

Successful farming venture require fish breeders to select broodstock for increased production in quality and quantity of fish seeds. Broodstock is a good predictor of fecundity and can be used to select fish of higher seed production.

Broodstock selection guide includes:

- Absence of body wound and parasites
- Absence of deformation of body and or fin
- Evidence of healthy and moderate fish growth; neither too fat nor too thin. The body should possess required shape, conformations and proportions.

Broodstock can be kept in different types of facilities: concrete tanks, hapa net cages installed in ponds or lake, and earthen ponds. The following facilities are suitable for tilapia broodstock:

i. Concrete tanks can be constructed with dimension 4 × 5 × 1 (m^3). Each compartment is designed with a catch basin occupying about 15-20% of the floor area with depth of about 10-12 cm. Catch basin serves to collect both the breeders and fry during harvest. Water is drained through a removable PVC (polyvinylchloride) stand-pipe (about 7 cm diameter) with perforations at 50-75 cm height to maintain the water level. It also serves as an overflow device and control of fish escape.
ii. Hapa net cages with mesh of 0.5 mm can be made with dimensions 3 × 3 × 2 (m^3). The cages in the lake can be suspended from a fixed bamboo post. Submerged at a depth of at least 1.0-1.5 m, leaving an allowance of 0.5-1.0 m of the net above the water surface. It is advisable to cover the cages to prevent entrance of predators.
iii. Earthen ponds with rectangular shape can have an area of 100-320 m^2 (10 × 10 or 16 × 20) per compartment. Each compartment is provided with water inlet and outlet, both of which are protected with a net. Water level in the pond should be maintained at a depth of at least 0.7m.

Four-month old tilapia with weights ranging from 100-250g can be suitable for breeding.

The stocking density varies according to rearing facility.

- In hapas, 5 females/m^2
- In concrete tanks, stock 4 females/m^2 without aeration and 6 females/m^2 with aeration.
- In earthen ponds 2 females/m^2. Separation and eventual paring at ratio 1:2, increased the output by more than 50% and growth rate of the fries by 25%.
- The sex ratio of male to female for all types of breeding facility ranges from 1:1-4. Most economical for fry production is 1:3. Therefore, for best hatchery practice it is sensible to stock one male to three females

- The premaxilla of the male fish should be removed by clipping with scissors to prevent injury or death of females during courtship (Plate 6).

http://fishconsult.org/?p=15144

Plate 6: Removed Maxilla of a Tilapia Male Fish

- The broodstock should be fed daily with formulated dry pellets with 25-35% dietary crude protein.
- The feed is given twice daily at feeding rate of 1-2% of the fish body weight.
- Remove the eggs to prevent the females from incubating their eggs orally. This allows for better control of hatching and allows for the female to produce the next batch of eggs. Collecting swim up fry is good method in place of incubating eggs which requires skilled personnel and facilities to ensure stable water flow and temperature at all time.
- In hatcheries, the sizes of tilapia broodstock is between 180g and 400g
- The female *O. niloticus* broodfish are usually smaller in size (<203g) than the male broodfish (>300g).

3.3 Seed Collection and Egg Incubation

Tilapias show some high degree of parental care to their eggs and fry. *Oreochromis niloticus and Oreochromis andersonii* are mouth brooders. They incubate eggs in their mouth till they are fully hatched (Plates 6 and 7). This kind of fry collection system is easy for smallholder hatchery farmers. Fry collection from ponds is usually every 7-21 days interval. The system is cheap and easy, but survival is low. Major disadvantage is that fry are not uniform in sizes thereby promoting cannibalism at stocking.

Plate 7: Eggs Collection from Mouth Brooder (Pink *Oreochromis niloticus*)

Plate 8: Fertilized Eggs in the Mouth of a Female Brooder (*Oreochromis andersonii*)

The method used to rear tilapia eggs varies with species. The female broodstock will be checked regularly for eggs. If they carry eggs in their mouths, they will be collected and transferred into the hatchery. Harvested eggs and yolk-sac larvae are transferred to the hatchery section where they are cleaned and washed with clean water first. They are then disinfected with 40% Formalin/Malachite mixture which is 4ml per 2 liters of clean water for 1-2 minutes and washed in clean water again. They are weighed and put in the incubator jars containing water which is passed through a recirculating system. The eggs must be kept in gentle motion for mouthbrooders mimicking entrance of fresh water into the mouth and goes out through the opercula opening.

Jar hatching has also been found to be a good way of hatching larger numbers with little supervision (Plate 8). Tray hatching can be a more effective method to use for creating best health conditions of fry and better control. However, the disadvantage is that it is very labour intensive and therefore not the most cost-effective technique. Use of hapa is a very convenient means of collecting and rearing tilapia fry (Plates 9 and 10). During egg development, a lot of ammonia and carbon dioxide may be produced which need to be flushed away by continuous flow through. If ammonia concentration exceeds 5 mg/l the growth of the fry may be inhibited, and the gills of developing fry may be damaged. The maintenance of pH between 6.5 and 7.5 is important to ensure healthy development. A pH below 4.5 or above 8.5 will result in high egg and fry mortalities. High pH and low water hardness may weaken the egg shells, thereby causing premature hatched eggs and weak fry. The eggs are mouth-brooded at 28°C and hatch within 96 hours. Tilapia eggs can be treated with chemicals (disinfectants) during incubation to control bacterial or fungal infections. Such include Formalin (1,000–2,000 mg/l) or Malachite Green (1–5 mg/l).

Plate 9: An Egg Incubator

Plate 10: Fry Collection from Hapa Breeding

Plate 11: Hapa Setup for Tilapia

3.4 Egg and Yolk-Sac Collection, and Larval Rearing

Broodstock should be inspected regularly at 5-days interval. Collected seeds usually have eggs at various stages of development: hatchlings, pre-swim-up and swim-up fry. To maintain the higher yields from frequent harvesting, the eggs need to be incubated artificially.

In big hatchery operations, eggs are collected every 5-7 days from the mouth of the females. This will guarantee quality and higher percentage of all-male sex reversed fingerlings are produced. However, 7 days interval egg collection are likely to have hatchlings in the mouth of the broodstock mixed with eggs. Fish is gathered on one end of the hapa nets where two nets are used to collect the breeders and water is used to flush the eggs from the mouth of the

brooder. This method gives a better control to have fry of good quality and better rate of success for sex reversal (98% minimum). Eggs and yolk-sac are separated into stages 1 to 5. Some stages can be combined if they are not too distinct.

Well oxygenated and clean water must be maintained for good result. Poor seed management will result in poor overall production. The larvae of all tilapia species have bulky yolks which make it difficult to swim or make them unable to swim, they sink. Therefore, it is important that they are kept in constant slow motion by the water which also keeps the system oxygenated. They rely on their superficial blood vessels on the tail and body for their oxygen supply because of the absence of functional mouths or gills.

The larvae of mouth-brooding species should be reared in the incubators until they become free-swimming. In hatching jars, the swim-up fry follows the flow of water out of the jar. The outflow can be channeled into the rearing tanks to minimize handling.

3.4.1 Biosecurity measures involved in Egg and Yolk-Sac Collection, and Larval Rearing

- Parent fish and the eggs must be handled with care
- Use well oxygenated and clean water in flow through
- Control entrance of visitors, staff, and other disease vectors to prevent transfer of infection.
- Hatchery operators must ensure optimum physical and chemical conditions of water, using reliable instrument to take measurements so that fish is not unduly stressed and predisposed to opportunistic bacterial infection.
- All hatchery equipment must be cleaned and disinfected regularly and allowed to dry.

3b.i. Leaning Activity:

Learning activity will be prepared that leads to discussion, remembering, memorizing, action on Module 3

3b. ii. Facilitation Methods

Facilitation methods to be used by facilitators include:

Lecture with audio-visuals

i. Brainstorming on issues raised

ii. Role plays on key issues

iii. Group discussion and feed-backs in plenary

3b.iii. Learning Materials: *Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content. Sequential narration of module will be accomplished in simple non-technical form.*

3b. iv. Output Evaluation/with Feedback: *Prepare evaluation questions based on the content/s you covered (could be open-ended or close-ended questions). Then prepare answers for learners to check their performance.*

Output Evaluation/with Feedback

1. What does incubator mimics in the tilapia broodstock?
2. What will be the effect of a high pH and low water hardness on the eggs?
3. Mention some physical biosecurity measure
4. Mention some chemical biosecurity measures?
5. If two males are stocked in a hapa, how many females are supposed to be in the same hapa?
   (a) 6 females (b) 10 females (c) 1 females (d) none of the above
6. The optimum pH for tilapia is
   (b) 6.5 - 7.5 (b) 1-2 (c) <4.5 (d) >8.5
7. Which of the broodstock will you choose if you were involved in a broodstock selection process?
   (e) Presence of wounds
   (f) Absence of body wound and parasites
   (g) Presence of deformation of body and or fin
   (h) All of the above
8. The number of eggs in one batch ranges from
   (b) 100-2,000 (b) 50-100 (c) 600000-1000000 (d) 340000-450000
9. Which of the following chemical treatment can be administered during egg incubation against fungal and bacterial infection?
   (a) Formalin (b) Oxytetracycline (c) methyl testosterone (d) vitamin premix
10. Biosecurity is important for the following reasons except
    (a) It minimizes the risk of project failure
    (b) Reduces viability and leads to eventual loss

(c) Reduces the chance of disease outbreak

(d) Reduces the chance of economic losses due to fish loss

MODULE 4

FEED PREPARATION AND MANAGEMENT PRACTICES

4a.i. Learning Outcomes/Learning Activity Bundle

For each learning outcome, prepare prompting questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module.

4a. ii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning.

Five questions should be prepared based on content of Module 4

1. What is a secchi disc used for?
2. What is the difference between physical biosecurity and chemical biosecurity?
3. What factor (s) encourages recirculatory system?
   (a) Environmental regulation is very strict.
   (b) Scarce water source.
   (c) Higher cost of land.
   (d) All of the above
4. What factor(s) encourages cage system?
   (a) There are abundant water bodies.
   (b) Good oxygen level in the water bodies.
   (c) No predator infestation in most of the water bodies.
   (d) Good market price.
5. Which of the following is not a technique of sex reversal?
   (a) Hormonal sex reversal
   (b) Hybridization
   (c) Visual Selection
   (d) Yolk sac vibration

4.1. Techniques for Sex Reversal Feed Preparation

There are four methods that can be used for mono-sex tilapia production.

- Hormonal sex reversal
- Hybridization (it should be noted that hybridization is not a recommended practice as this leads to mixing of strains and loss of pure genetic strain in the area or region)
- Visual Selection
- Genetic manipulation.

Hormonal sex reversal is the most commonly method used. The use of hormonal sex reversal is practiced in many countries; however, it is very sensitive. For example, in India, stocking of only mono-sex tilapia is allowed only in line with the national guidelines. This manual is not advocating for the use of Methyl or Ethyl Testosterone hormone but teaching on the commonly used and available techniques. Newly hatched larvae are fed with hormone feed for between 21 to 23 days. By the 10^{th} day after hatching, when the gonad of the fry still remains in an undifferentiated stage, the sex reversal feeding can commence. Commonly used sex reversal hormone is 17alpha methyl testosterone or 17alpha ethyl testosterone.

4.2. Better Aquaculture Practices (BAP) Guidelines on Use of Methyl Testosterone or Ethyl Testosterone for Hatcheries

- When hormones are used to produce mono-sex fry, records of hormone applications shall be maintained.
- Workers who work with methyl testosterone, ethyl testosterone or other sex-reversal should be trained in handling of the hormones.
- Workers will be required to wear protective clothing and masks with air filter.
- The facility should have a protocol for managing water used for sex-reversal. Hormone treated water should not be released into the environment directly. There must always be compliance with government standards, where these exist.

4.3. Better Aquaculture Practices (BAP) Guidelines on Use of Methyl Testosterone or Ethyl Testosterone for Farms

- The use of methyl testosterone for sex-reversal of fry is permissible, provided it is not banned by the importing country.

- Workers should be instructed to wear protective clothing and mask with air filter when working with the hormone.
- When the hormone is used, records of application should be maintained.
- Minimum hold time required before any water in which fish has been treated or fed with feed containing methyl or ethyl testosterone can be released to the environment is only after 48 hours.

4.4. Principle of sex reversal

- The process raises the level of male steroid in the bloodstream of sexually undifferentiated (before they have physically become male or female, usually between 21 to 28 days after hatching) fry

Preparation of the hormone-feed mix

- It must be ensured that feed is of good nutritional quality and highly palatable Crude Protein levels of up to 45% is used.
- Dry ingredients should be sieved with a sieve of mesh screen 0.6 mm.
- Stock solution of hormone: Dissolved exactly 4-6 g. of methyl testosterone in exactly 1.0 liter of 80-95% ethyl alcohol which is enough to treat approximately 300,000 fry

Procedure for mixing the ingredients

- Take alcohol – hormone stock solution of 10 ml. to 500ml Ethyl or isopropyl alcohol to dry ingredients of 1,000 g (1kg).
- Prepare the ground and sieved dry feed ingredients
- Mix the alcohol-hormone stock solution with the alcohol.
- Add the above solution slowly and mix with the dry feed ingredients.
- Allow the alcohol to evaporate at room temperature with no direct sunlight by spreading out the mixture to a maximum thickness of 3 to 5 cm. Mix lightly by hand 2 or 3 times.
- Treated feeds can be packed once the mixture feels dry to the touch and all the odor of the alcohol has disappeared. Store the treated fish feed at 4 ^{0}C

Materials for I kg of sex reversal feed

- 1 kg of 0.2mm (with at least 40% protein) feed.
- Quantity of hormone: 4 -5g of 17 alpha Methyl Testosterone (MT) hormone.
- 1,000ml of 95% ethyl alcohol (WorldFish Abbassa recommendation).

This quantity is sufficient to treat 300,000 fry.

Preparation

- Mix very well, 60mg of hormone with 240ml of 98% ethanol.
- The mixture should be to 1kg feed. Homogenous mix required.
- Spread the mix in a single layer, then, dry the mix but not directly in the sun.

Factors which are important to ensure good and efficient sex reversal include:

- Age of fry must not be above 17 days.
- Correct hormone dose (4-5 mg).
- High palatability of feed (25-45% protein).
- High frequency of feeding (3-6 time per day).
- Lack of disease
- Optimum temperature (<32 ^{0}C)
- Ensure even size of fry to prevent cannibalism.
- Control level of natural food.
- Protect storage of the hormone and hormone treated feed 4 ^{0}C.
- Optimum fry density (1,000/m2 or 12 fry/liter)
- Treatment duration should take a minimum of between 25 to 28 days for more reliable sex reversed success.

After a 25 – 28 days treatment, few fry are less than 14 mm. However, if more than 5% are 13mm or less, those individuals should be removed because 25% of them may be females. Recommended feeding schedule for Tilapia is shown in Table 1.

Table 1: Weekly Feeding Schedule for Tilapia

Days	Weight	Log_w	Specific Growth Rate	Weight Gain
1	0.03	-1.52288	0	0
29	0.8	-0.09691	5.092745	0.77
34	1.7	0.230449	6.547179	1.67
36	1.8	0.255273	1.241179	1.77
59	8.2	0.913814	2.863223	8.17
62	13	1.113943	6.670983	12.97
64	17	1.230449	5.825278	16.97
65	21	1.322219	9.177037	20.97

80	30.3	1.481443	1.061489	30.27
87	37	1.568202	1.239416	36.97
90	43.5	1.638489	2.342918	43.47
97	47.48	1.676511	0.543164	47.45
105	59.5	1.774517	1.225078	59.47
112	62.6	1.796574	0.315105	62.57

4.5. Water Quality Management

Water quality affects fish health and survival at extreme conditions. Tilapia does well in high quality water and the following physico-chemical properties:

- Secchi disc reading is good when at 60cm.
- Tilapia strive well in a temperature between 27 -31^{0}c. Suspend feeding the fish at a lower temperature during cloudy hour/day.
- Uneaten feed and faecal deposit leave a lot of dirt in the water resulting in high ammonia level.
- Dissolved oxygen (DO) should not be less than 5-6mg/l and pH range of 7-9 are suitable for enhanced growth of tilapia. Aeration should be incorporated if the DO is low.
- Optimum temperature is 27-31^{o}C, however tilapia survive at 20-40 ^{o}C, but below 10^{o}C could be lethal.
- Dissolved oxygen of 5-8mg/l and pH range of 7-9 are suitable
- Salinity: tilapia is a fresh water fish and may be able to tolerate brackish water up to 12-15ppt.
- Ammonia: production in ponds depends on quality of feed and feeding rate, temperature, and size of fish. Concentration should be maintained below 0.1mg/l.

  -Level of ammonia can be related to pH; at pH 7, higher level of ammonia can be safe.

  -Alkaline level (pH>9), ammonia can be dangerous to the fish.

  -Nitrite is a toxic pollutant to fish. It is produced by bacteria during the break down of ammonia through the process of nitrification. Tilapia fish start to die at nitrite concentration of 5mg/l and high level of can cause brown blood disease.

  Regular flushing of pond water helps in reducing accumulation of pollutants in the system. Salt can also be added to disinfect pond water at 1g/10litres of water

Other precautions in water quality management in rearing tilapia are:

- Non-ingested food and fecal deposits should be washed out daily by removing and replacing 10-20% of the water.
- Algal growth on the walls of the troughs should be removed once in every 6-8 weeks by scrubbing.
- Flow through of 23 to 46 liters per minute is needed for adequate DO for 45.4kg of tilapia, without the use of aerators.
- When there is no water quality test kit, refusal of fish to take feed may be an indication of bad water quality.
- Avoid over feeding. Feeding rate should be 15 to 20% of fish weight daily until fry reach an average length of 15 mm (0.01 g). At that stage, feeding rate drop to10% of fish weight daily until the end of treatment.

4.6. Tilapia Culture Facilities

1. Earthen Pond

This is the first preference especially in areas where:

- Temperature is suitable.
- Land is abundant and cheap.
- Environmental regulations are not too strict.
- There are abundant and suitable water sources (Plate 12).
- Cost of fish is not too high.
- Higher technical manpower is not required.

Plate 12: Stocking of Tilapia Fingerlings in a Pond

2. **Cage Facilities**

This is preferred next to earthen pond. Suitable in areas where:

- Temperature is suitable.
- There are abundant water bodies.
- Good oxygen level in the water bodies.
- No predator infestation in most of the water bodies.
- Good market price.
- No source of pollution closer to the water bodies.

Cage culture production cost may be 25-40% higher than pond (Plate 13).

Plate 13: Tilapia Cage Culture System

3. **Re-Circulatory System**

This is suitable where:

- Environmental regulation is very strict.
- Scarce water source.
- Higher cost of land.
- Temperature is low.
- Project located in urban areas.
- Fish commands higher selling price.
- Continuous electricity supply at affordable price.
- Qualified staff or manpower.

Cost of production can be 80-120% higher than in earthen pond (Plate 14).

Plate 14: Re-Circulatory System Facility

4.7. Routine Management Practices, Use of Hapa and Probiotics

4.7.1 Routine Management Practices

Good management practice involves routine or regular checking and monitoring of fish ponds including water quality and depth, as well as inlet and outlet of production facilities. It is important to monitor and check the following on daily bases:

- Main water intakes: feeder canals and pond inlets must supply adequate water to ponds and hatchery.
- Check and confirm that all pond structures are functioning well
- Water quality checks using water test kit or by visual assessment. The latter requires experience and can be done by observing:
  - -The behaviour of the fish
  - -Plankton turbidity
  - -Water colour which is expected to be greenish
- Feeding of fish
- Record keeping

Weekly tasks or longer intervals should include the following:

- Checking of dykes and structures for possible leaks when complete draining is done
- Removal of bottom muds if present
- Control of aquatic weed and pests
- Routine water quality check
- Assessing fish stock through test cropping. This helps to determine:
  - Efficiency of feeding

- Adjustment of daily feeding ration which saves feeding cost.
- Quality of fish growth
- Stocking rate, if it is too high, bigger fish will be cropped out.
- General health condition of the fish stock

- Record keeping for resource use efficiency and stock inventory.
- Calculation of various parameters for managerial decision making. Examples are:
  - Feed conversion ratio (FCR)
  - Daily growth rate (g/day)

The fish farmer should stock only best grade of fingerlings. It is important to grade hatchlings and fingerlings as many times as possible. Depend less on chemical and antibiotics in fish health management. Use more probiotics if the technology is available. Ensure fishing gears are sanitized. Other cautions are:

- Restrict movement to the hatchery.
- Keep new incoming stock in quarantine tank.
- Store feed in cool and dry environment and use within 3 months of receipt.
- Avoid stocking the last grade (smallest fingerling size) of a production batch.

4.7.2 Use of Hapa and Probiotics

- Hapa is a cage like, rectangular or square net impoundment placed in a pond for holding fish for various purposes. They are made of fine mesh netting material. Hapa is used for rearing tilapia fry to fingerlings; thereby increasing survival rate at harvest. Hapas (fish holding netted bags) can be disinfected and preserved longer by soaking with urea for 10 days on the average.

- Probiotics is used to boost fish immunity (resistance to diseases), and achieve shorter cycle of production due to faster growth rate. Include probiotics in fingerlings' feed with 10-strate enzyme for better result. For example, a batch of tilapia hatched and at five weeks, the fish seeds were 1.8g and escapees (shooters) were 3.7g. This is more than 100% result compared to the normal growth rate without probiotics.

4.8. Biosecurity

Biosecurity is a set of preventive measures put in place to reduce the chance or risk of transmission of infectious diseases by pathogens (viruses, fungi, bacteria and parasites) or

disease outbreak. It is also designed to reduce the access of vectors (wild fish, predators, pests, rodents, domestic animals, livestock and people).

The main goal of implementation of biosecurity measures is to protect the farm and the surrounding environment from the introduction or spread of pathogens. These can come from the water source, seed source, feeds, equipment, personnel or waste.

There are different types of biosecurity measures:

- Physical biosecurity measures
- Chemical biosecurity measures

Physical biosecurity measures are those that aim at preventing the intrusion of disease-carrying vectors to the farm site. These include physical barriers, water treatment and quarantine. Chemical measures are those used to treat materials before they enter the facility. Other elements of biosecurity are to minimize impacts of invasive alien species on the environment and avoidance of health risks that may arise through consumption of fish.

The following precautions and biosecurity measure can be observed as BMPs on farm biosecurity:

- Seed should be healthy and free of disease: animals entering the farm can present a significant disease risk, especially if the health status is unknown. Therefore, seed should be bought from reputable hatcheries. If possible, fry should be quarantined before stocking in the ponds. This can be done through isolation in a hapa or in a small pond with no other fish.
- Limit entry points into the farm. This will make it easier to monitor compliance with biosecurity measures.
- Ensure wash down with a broad-spectrum disinfectant on vehicles; otherwise, the vehicles should be parked away from facilities.
- Wash hands at the farm entrance, before and after farm activities.
- Footbath should be installed at farm entrance.
- Avoid contact with sick animals.
- Avoid touching of eyes, mouth and ears.
- Maintain social distance amongst workers and between workers and customers.
- Disinfect farm tools regularly.

1. Facility entrance: indiscriminate entrance into the facility heightens the chance of contamination and transfer of pathogens.

- Control or restrict entrance of vehicles, visitors, staff, and other disease vectors to prevent transfer of infection.
- Hand wash and footbath must be present at the entrance.
- Wheels of vehicles should be disinfected to as they enter.
- Regular change of disinfectant.

2. Water management: water quality is the most important factor in ensuring fish health.

- Hatchery operators must ensure optimum physical and chemical conditions of water, using reliable instrument to take measurements so that fish is not unduly stressed and predisposed to opportunistic bacterial infection.
- Water used in production must be treated to kill pathogens, using chlorine, ozone, UV, ultrafiltration etc.

3. **Disinfecting equipment:** all hatchery equipment should be properly cleaned and disinfected after use and before any production cycle.

- Maintain a clean work environment, do not take hatchery equipment outside the facility or use them in other places.
- Disinfect all hatchery equipment regularly and dry them thoroughly.
- Flush sand filters and remove the sand to dry under the sun.
- Keep nets and other equipment away from the floor.

4 Quarantine incoming broodstock, fingerlings or juvenile: incoming broodstock or fish from other farms could be a vector of disease into the facility. Prophylactic treatment is given to rid the fish of parasites and bacteria before introduction into hatchery facility.

- Prophylactic treatment in hatchery include medicated baths in formalin, Oxytetracycline etc.
- Prophylactic treatment can be repeated three to four times within a week.
- It is good to allow flow-through when treatment is not ongoing.
- Fish can be fed when not undergoing treatment.
- Smooth inner surface in tanks allow easy and complete cleaning.
- During quarantine, fish should be closely monitored.

- Apart from quarantine treatment, broodstock should be given regular prophylactic treatment with or without Oxytetracycline at least once in a month.

***4b.i. Leaning Activity*:**

Learning activity will be prepared that leads to discussion, remembering, memorizing, action on Module 4

4b. ii. Facilitation Method

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raise
iii. Role plays on key issues
iv. Group discussion and feed backs in plenary

4b.iii. Learning Materials: W*rite narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content. Sequential narration of module will be accomplished in simple non-technical form.*

***4b. iv. Output Evaluation with Feedback*:**

1. What instrument is used to check water clarity?
2. Limit entry points to into the farm. Why is this important?
3. Pathogen can come from the water source, seed source, feeds, equipment, personnel or waste. True or false?
4. What is the difference between physical biosecurity and chemical biosecurity?
5. What factor(s) encourages recirculatory system?

(a) Project located in urban areas.
(b) Fish commands higher selling price.
(c) Continuous power supply at affordable price.
(d) All of the above

6. When can sex reversal feeding of tilapia commence?
   (a) 21st day (b) 10th day (c)27th day (d) none of the above
7. Water used in production must be treated to kill pathogens using
   (a) Chlorine (b) ozone (c) UV (d) all the above

8. What factor(s) encourages cage system?

(a) No predator infestation in most of the water bodies.

(b) Good market price.

(c) No source of pollution closer to the water bodies.

(d) All of the above.

9. Sex reversal in tilapia

(a) Raises the level of male steroid in the bloodstream of sexually undifferentiated fry

(b) Raises the level of female steroid in the bloodstream, of sexually undifferentiated

(c) Suppresses the level of female steroid in the bloodstream of sexually undifferentiated fry

(d) Suppresses the level of male steroid in the bloodstream of sexually undifferentiated fry

10. Which of the following is not a technique of sex reversal?

(a) Hormonal sex reversal

(b) Hybridization

(c) Visual Selection

(d) Yolk sac vibration

MODULE 5

FISH HEALTH AND DISEASE MANAGEMENT

5ai. Learning Outcome/Learning Activity Bundle

For each learning outcome, prepare prompting questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module.

5aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning.

Pre-Evaluation with Feedback

1. Which of the following is not an external factor that affect fish health?

(b) Geology (b) Industry Sewage (c) Sewage (d) Excreted waste

2. Which of the following is not an internal factor that affect fish health?

(a) Feed management (b) Soil (c) Water exchange (d) Maintenance

3. Which of the following is not a type of disease?

(a) Parasites (b) Fungi (c) Bacteriophage (d) Virus

4. Which of the following is not a sign of sickness in fish?
   (a) Fish stop feeding. Healthy fish should eat aggressively if fed at regularly scheduled times.
   (b) Ragged fins
   (c) Hyperactivity
   (d) The entire stock or a few may appear lethargic.
5. Are fungi primary or secondary problems?

5.1 Factors Affecting Fish Health

Fish health management is a term used in aquaculture to describe management practices that are designed to prevent fish infections and diseases, and to control diseases in cases of occurrences. Once fish get sick, it can be challenging to rescue them (Figure 1). Successful fish health management begins with prevention of disease rather than treatment. Prevention of fish disease is accomplished through good water quality management, nutrition, and sanitation.

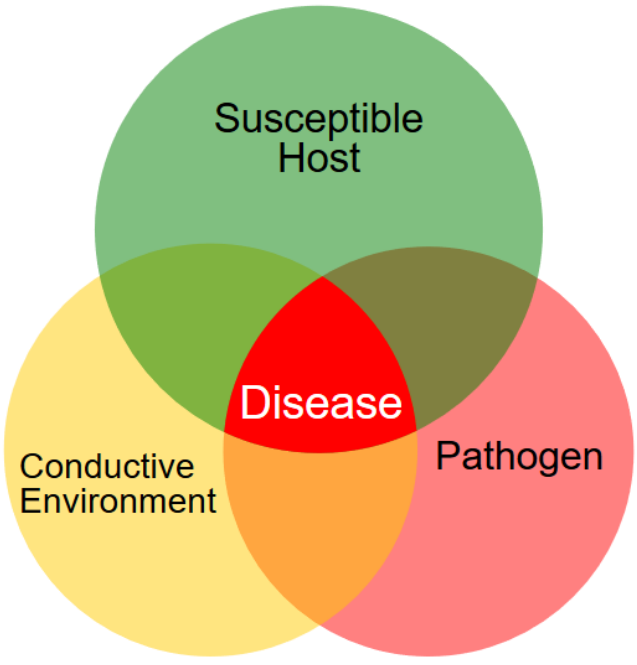

Figure 1: Classes of Factors that Affects Fish Health

Daily observation of fish behavior and feeding activity allows early detection of health problems when they do occur so that a diagnosis can be made before majority of the population becomes sick. Treatment will be successful if it is implemented early following the occurrence of a disease while the fish stock is not seriously infected.

Fish disease is significant to aquaculture because it leads to substantial economic loss and reduction in market value of fish. (Plate 15). Production costs are increased by fish disease outbreaks because of loss of fish (mortality), cost of treatment and decreased growth during recovery. In nature we are less aware of fish disease problems because sick animals are quickly removed from the population by predators. In addition, fish are less crowded in natural systems than in captivity or culture system.

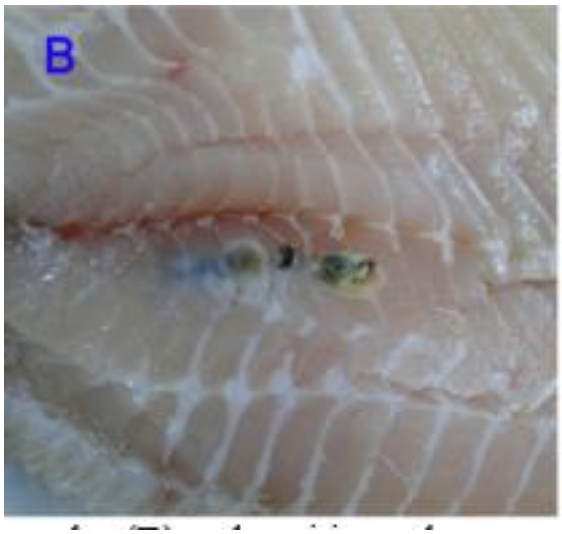

Plate 15: Fish muscle with holes and lesions.

5.2. Types of Fish Diseases

There are two major categories of diseases: infectious and non-infectious diseases. Infectious diseases are caused by pathogenic organisms present in the environment or carried by other fish species. They are contagious diseases and treatment may be necessary to control the outbreak. Infectious diseases are broadly categorized as parasitic, bacterial, viral, or fungal diseases (Figure 2).

Non-infectious diseases are caused by environmental problems, nutritional deficiencies, or genetic anomalies. They are not contagious and usually cannot be cured by medications.

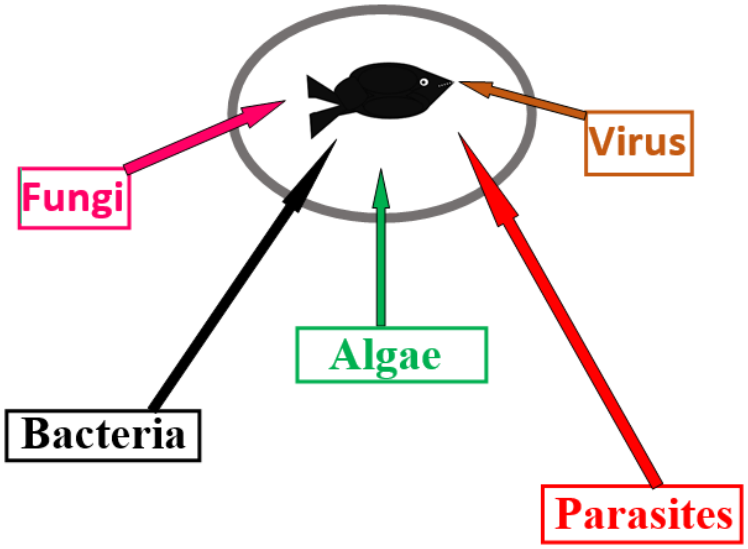

Figure 2: Biotic Factors that Affects Fish Health

5.2.1 Infectious Diseases

i. Parasitic diseases of fish are frequently caused by small microscopic organisms called protozoa which live in the aquatic environment. There are several classes of protozoans which target the gills, gut, skin thereby causing irritation, weight loss, and even death in severe cases death. Most protozoan infections can be controlled by the use of standard fisheries chemicals such as copper sulfate, formalin, or potassium permanganate.

There are broadly two types of parasites:

- Ectoparasite: are organisms that live on the skin of another organism called a host, from which they derive their food. This process in which they derive food and or protection is at the detriment of the host capable of costing its life. Examples of ectoparasites of the African catfish are *Ichthyophthirius multifiliis* (Ich or fish louse), *Gyrodactylus* and *Trichodina species*.
- **Trichodina (parasitic disease put in the middle of bacterial disease discussion), bring it under parasitic**

  Trichodina is a protozoan parasite that has severely affected production at many facilities. It can result in extremely high mortality rates, particularly in young fish. The parasites heavily infest the gill and body surfaces of infected fish.

Diagnosis and Control

Infected fish display flashing (swimming against floors of tanks to scrape parasites off), rapid breathing, weakness, and uncoordinated swimming. Since it attacks the gills, the gills are less efficient in absorbing oxygen, realizing carbon dioxide, excreting ammonia, and maintaining chemical balance between their body and the environment.

Trichodina can be temporarily controlled with copper sulfate and salt. Treated fish remain carriers even after treatment, and much like Streptococcus, it is nearly impossible to eliminate Trichodina from a system once it has been introduced. Any fish outdoor ponds or other farms should be carefully examined for Trichodina before letting them on your premises.

- Endoparasite: are organisms that live on the inside of another organism called a host, from which they derive their food. They exist in two forms: intercellular parasites and intracellular parasites. Intercellular parasites are those that inhabit spaces of the host body such as nematodes, tapeworms, and other helminthes. Helminthes live in the gut of their hosts. Intracellular parasites are endoparasites that live within the cell of the host such as protozoan.

ii. Bacterial diseases are often internal infections. Bacterial diseases can also be external, resulting in erosion of skin and ulceration. Columnaris is an example of an external bacterial infection which may be caused by rough handling. Bacterial opportunistic pathogens are microorganisms causing disease in hosts predisposed to environmental stressors or reduced immune function. Stress factors like hypoxia, high ammonia concentration, abnormal pH, and high population density makes it possible for the opportunistic pathogens to thrive. Typically, fish infected with a bacterial disease will have hemorrhagic spots or ulcers along the body wall, around the eyes and mouth. They may also have an enlarged, fluid-filled abdomen, and protruding eyes. Most bacterial infection are seen when the fish immunity has been compromised or when a parasitic infection has opened the way. This makes these bacteria in such cases to be secondary infection.

- **Columnaris**

  Columnaris is caused by *Flexibacter columnaris*. Stress predisposes fish to this infection. Outbreaks generally result from temperature fluctuations, trauma from poor

handling especially in younger fish, and poor water quality, crowding and poor nutrition increases severity of the disease.

Diagnosis and Control

Infected fish generally show lethargy, anorexia, weak swimming, and mortality. Raised white patches appear on the skin or fins and may later develop into ulcers. Certain antibiotics, copper sulfate and potassium permanganate are reported to be effective for temporary treatment.

- **Aeromonas**

  Another bacterial disease that has significantly impacted production in farms is the disease Aeromonad septicemia ("*Aeromonas*"). This disease is caused by the bacteria *Aeromonas hydrophila.*

  Diagnosis and Control

  Aeromonas results in the clinical signs of generalized hemorrhagic septicemia such as lethargy, weakness and loss of appetite. Other signs are red discoloration at the anus and the base of the fins, hemorrhagic eyes, gills, internal organs, and muscle, blood tinged abdominal fluid, and swollen kidney, spleen, and liver. *Aeromonas* generally affects systems that have systemic poor water quality or over-crowding. *Aeromonas* temporarily responds to antibiotic therapy, but if a farm has *Aeromonas,* they really need to either change their source of fish seed or improve the farm's husbandry. Always avoid getting fish from infected stocks at all costs.

iii. Viral diseases are difficult to distinguish from bacterial diseases without special laboratory tests. They are difficult to diagnose and there are no specific medications available to cure viral infections of fish. Consultation with an aquaculture or fish health specialist is recommended if you suspect a bacterial or viral disease is killing your fish.

iv. Fungal spores exist freely in the aquatic environment, but only affect unhealthy fish. Healthy fish tend to be immune. When fish are infected with an external parasite, bacterial infection, or injured by handling, the fungi can colonize damaged tissue on the exterior of the fish. These areas appear to have a cotton-like growth or may appear as brown matted areas when the fish are removed from the water. Formalin or Potassium Permanganate are effectively used to treat most fungal infections. Since

fungi are usually a secondary problem, it is important to diagnose the original problem and correct it as well.

5.2.2 Non-infectious diseases

These are broadly categorized as environmental, nutritional, or genetic. Environmental diseases are the most important in commercial aquaculture. They include low DO, high ammonia, high nitrite, natural or man-made toxins in the aquatic environment. Proper techniques of managing water quality will enable producers to prevent most environmental diseases.

5.3 Quick Signs observed when your Fish is Sick

These signs can be observed in fish seeds as they grow from fingerling to juvenile stage. The most obvious sign that shows something is wrong within the culture system, is the presence of dead or dying fish. This is because a careful observer would notice a change in the behaviour before mortalities begin (Table 3).

Quick signs are when:

- Fish stop feeding. Healthy fish should eat actively if fed at regularly scheduled times.
- The entire stock or a few may appear lethargic or sluggish.
- Fish observed hanging lazily in shallow water, gasping at the surface or rubbing against objects. These behavioral abnormalities indicate that the fish are not feeling well or that something is irritating them.
- The presence of sores (ulcers or hemorrhages).
- Ragged fins.
- Abnormal body shape (i.e., a distended abdomen or "dropsy" and exophthalmia or "popeye")

When these abnormalities are observed, the fish should be evaluated for parasitic or bacterial infections.

Table 3: Characterization and Differentiation of Sick and Healthy Fish

Fish condition	Healthy fish	Sick fish
Escape reflex (Determined in water)	Fish react to any external stimuli like sound or vibration	Lose ability to react to any stimuli and they are easily caught
Defensive reflex	Toss about and flab about when laid on a table	sluggish and remain motionless
Tail reflex	Show the caudal fin stretched in fan shape	Hang the caudal fin vertically downward.
Ocular reflex	Fish try hard to keep the eyeball in normal position.	Fish lose this reflex.

5.3.1 What to Do if Your Fish are Sick

If you suspect that fish are getting sick, the first thing to do is check the water quality. Low oxygen is a frequent cause of fish mortality in ponds, especially in the summer. High levels of ammonia are also commonly associated with disease outbreaks when fish are crowded in vats or tanks. In general, check dissolved oxygen, ammonia, nitrite, and pH, during a minimum water quality screen associated with a fish disease outbreak. The parameters of significance include total alkalinity, total hardness, nitrate (saltwater systems) and chlorine (if using city water).

Daily records are very important as it will be a reference point to trace what may have gone wrong and for general management. The record should include the dates fish were stocked, size of fish at stocking, source of fish, feeding rate, growth rate, daily mortality and water quality. Good records include also a description of behavioral and physical signs exhibited by sick fish, and results of water quality tests. These will provide a complete case history for easy diagnosis and information about management and prevention of future cases.

5.4 Environmental and Nutritional Deficiencies

5.4.1 Environmental Deficiencies

Oxygen Depletion

Oxygen depletion, or hypoxia, is a common effect of eutrophication in water. The direct effects of hypoxia include mortalities especially in fish that need high levels of

dissolved oxygen. Low dissolved oxygen can result in high mortality of fish seeds and consequently serious financial consequences for commercial fish operations.

(a) Signs of Low DO in Pond Water

Sometimes fish farmers may be confused differentiating between tilapia swimming due to low DO and normal fish behaviour. When the water system is normal, the fish darts back and forth the surface, but when it is due to low DO, they tend to be slow and in a hanging position (Plate 15). Although fish when fully fed, can show such behavior, it is therefore important for the fish farmer to differentiate from those hanging due to low DO.

(a) Signs of Pond Oxygen Depletion

- Fish gasping at the surface of a water are likely oxygen starved.
- Foul odours in poorly oxygenated ponds, decaying vegetation, excess fish waste, and other organic matter can emit distinct smells.

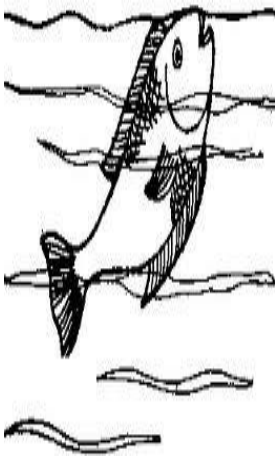

Plate 16: Fish gasping for air at the surface of water

Fish production can be greatly affected by excessively low or high pH. Extreme pH values can kill your fish. Growth of natural food organisms may also be greatly reduced. The critical pH values vary according to the fish species, the size of individual fish and other environmental conditions.

Purpose of measuring the level of unionized ammonia is to manage pond pH:

- Above 8.5 at sunrise, you can use acid fertilizers.

- Below 6.5 (at sunrise), use lime and alkaline fertilizers

(c) Clay turbidity in pond water

Clay turbidity in pond water (muddy water) can be harmful to fish and limit pond productivity. Low phytoplankton density in ponds means less food and DO for the fish. On the other hand, too much (algal bloom) lead to minimized sunlight penetration causing algal deaths. Less phytoplankton and decomposing plankton also lead to less food and DO for the fish. Therefore, good water quality has required plankton density of 30 cm (Plate 16).

Plate 17: Monitoring the pond turbidity

5.4.2 Diseases Due to Nutrient Deficiency or Irregularities

(a) Dietary Essential Amino Acid (EAA) deficiency and Toxicity

Poor feed formulation due to the use of disproportionate amounts of feed proteins with natural specific deficiencies of Dietary Essential Amino Acid (EAA) deficiencies may arise from excessive heat treatment of feed proteins during feed manufacture. Nutritional pathologies also arise from the consumption of feed proteins containing toxic amino acids. Some feed proteins contain toxic amino acids which have impacts negatively on fish growth and efficiency. It may lead to eventual fish death. There are toxicity symptoms of scoliosis, deformed opercula, scale deformities, scale loss, and spongiosis of epidermal cells. These occurs when dietary content of leucine is over 13.4%. Some general symptoms of protein deficiency are dorsal or caudal fin erosion, cataract, decreased carcass lipid content and renal calcinosis.

(b) Dietary Essential Fatty Acid Deficiency and Toxicity

When fish is fed with feed deficient in EFA, they tend to display reduced growth and poor feed efficiency. This can be due to poor feed formulation or from the use of live food organisms that are deficient in EFA. Dietary excess of EFA may exert a negative effect on fish growth and feed efficiency. Cyclopropenoic can be toxic to fish. It is a toxic fatty acid found in the lipid fraction of cottonseed products. This toxic FA can reduce growth rate, result in extreme liver damage, it increases glycogen deposition and decrease protein content, and a decrease in activity of several key enzymes. General Symptoms of Deficiency and Toxicity in Tilapia include marked congestion, haemorrhage in dermal vessels around snout and at bases of pectoral/dorsal fins. Others are lordosis, exophthalmia, oedema, orbital collapse, darkening of liver, marked distension of bile duct, deposits of intracellular ceroid in liver, spleen, kidney and choroid resulting to increased mortality.

(c) Hypervitaminosis and hypovitaminosis

Hypervitaminosis in fish is a condition that occurs when the fish has accumulated too much vitamin in their body. It is caused by fat-soluble vitamins because they are stored in the fish body longer than the water-soluble vitamins. Under certain conditions it is so high that it results in a toxic condition. Such fat-soluble vitamins are Vitamin D and A. Most recorded cases of hypervitaminosis in fish occurred under experimental conditions and are hardly found to occur under normal catfish culture conditions.

Hypovitaminosis on the other hand, is vitamin deficiency which may be caused by inadequacies in nutrients, malabsorption of nutrient from feed, presence of dietary anti-vitamin factors, dietary antibiotic addition or effects of pharmacological agents, and abnormalities of vitamin metabolism or utilization in the metabolic pathways, feed processing and storage. Fish with vitamin deficiency can have symptoms such as scoliosis, lordosis, reduced growth/wound repair, internal/external haemorrhage, caudal fin erosion, exophthalmia, anaemia and reduced egg hatchability.

(d) Dietary essential mineral deficiency and Toxicity

Minerals can either be macro minerals (minerals needed in large quantities) or microminerals (minerals needed in minute quantities but are equally very important in diet). Deficiency in minerals can lead to problems in physiological functions within the fish. Some symptoms of deficiency of minerals in fish are skeletal deformity, abnormal calcification of bones, cranial

deformity, reduced growth, poor feed efficiency, bone demineralization, low carcass ash, Calcium and Phosphorus, anaemia, anorexia, sluggishness and muscle flaccidity.

Toxicity of minerals in fish are usually associated with the use of unconventional dietary feed ingredients which may have heavy metal contaminants. Some of such contaminants include copper, lead, cadmium, mercury, arsenic and lead.

***5b.i. Leaning Activity*:**

Learning activity will be prepared that leads to discussion, remembering, memorizing, action on Module 5.

5b. ii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raise
iii. Role plays on key issues
iv. Group discussion and feed backs in plenary

5b.iii. Learning Materials: (W*rite narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content). Sequential narration of module will be accomplished in simple non-technical form.*

***5b. iv. Output Evaluation with Feedback*:**

Output Evaluation with Feedback

1. Which of the following is not an external factor that affect fish health?
   (c) Geology (b) Sewage (c) Soil(d) Virus
2. Which of the following is not an internal factor that affect fish health?
   (a) Cleaning (b) Geology (c) water exchange (d) maintenance
3. Which of the following is not a type of disease?

(b) Fungi (b) Symbiosis (c) bacteriophage (d) Virus

4. Which of the following is not a sign of sickness in fish?
   (a) Voracious feeding
   (b) Gasping at the surface

(c) Abnormal body confirmation

(d) The entire stock or a few may appear lethargic.

5. Are parasites primary or secondary problems?
6. What would you recommend to a fish farmer with a pH problem reading above 9 in the morning?
7. What is/are the effect(s) of diseases in fish?
8. What is the remedy for water pH below?
9. Is the statement below right or wrong?

Some fish diseases are infectious while others are not infectious.

10. Potassium permanganate can be used to control water turbidity. True or false?

MODULE 6

BUSINESS PLAN DEVELOPMENT

6a.i. Learning Outcomes/Learning Activity Bundle

For each learning outcome, prepare prompting questions that leads to participants' sharing their experience about the intended contents (experiential learning).

6a. ii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide, this could be open or close-ended. Five simple questions should be raised on Module 6.

6a. iii. Pre-Evaluation with Feedback

1. Is a business plan important? Give a reason
2. One of the following is not part of a business profile

(a) Shirt colour (b) Business Name (c) Head Office Address (d) Company Status

3. Would you classify fish farming as capital intensive or otherwise? Give reason(s)
4. Is Return on investment a market analysis or financial analysis?
5. Market analysis involves the following except

(a) Market need (b) demographics and segmentation (c) competition (d) profit margin

6.1. Purpose of Business Plan

A business plan is a step by step blueprint of how you will operate your business. It provides direction for every decision made. Primarily, a business plan has two main purposes. First, it is used to run a company/business with a clear and more consistent vision. Secondly, it is required to facilitate access to funding such as loans and grants for business.

A business plan is used to manage an organization/business by stating the goals, how they will be achieved and when. The plan will also summarize what the business is about, why it exists and where it will go. It serves as a point of reference to partners, investors, employees and management to assess progress with reference to its objectives.

6.2. Business Profile

A business profile is a list of basic details about a company. It highlights the strength of the company to prospective clients and customers. It is a form of résumé that communicates a company's values, objectives, services, products and current status.

A simple business profile format includes:

- Business Name
- Head Office Address
- Phone Number
- Website Address
- Company Status
- Contact Information of the Person in Charge (name, phone number and email address)

6.3. Organization and Products

Business organization details include:

- Date of registration and commencement of business
- Main areas of business activity
- Main product lines
- Main services
- Principal customer in industries and across geographical boundaries
- Business capacity in terms of:
    - Human resources - Business organization and number of employees
    - Financial - Financial circumstances of business (Optional)

- Technical - Company capacity for project in terms of staff qualifications/certification.
- References to success stories in a similar project.

6.4. Description of Management Team

The management team is the group of individuals that organize the business strategy and ensure business objectives are met. They operate at the higher level of an organization and are responsible for day-to-day managing of other teams or individuals. Description of a management team should help third parties to recognize what set the business apart.

6.5. Market Analysis

Market analysis is a qualitative and quantitative assessment of a market's attractiveness and its dynamics. These include market size (volume and value), buying patterns or preference of customers, degree of competition, economic environment, including demand and supply forces, and various customer segments. Market analysis helps to gain an insight or understanding of potential customers and competitor. It is therefore useful in identifying a niche for the business or in developing a marketing strategy. The process involves the following:

1. Demographics and Segmentation is the division of the market according to age, race, gender, family size, religion, ethnicity, education and income, all of which give direct information on market size. It points to target market and market need. The first step in the process of market analysis is measuring the market size. Market size refers to the maximum total quantity of sales or number of customers your business has or the total potential number of customer or quantity of sales in a given year. Measurement of market size can take two approaches - volume and value. Volume deals with the number of customers while value is the estimated monetary worth of the proposed business. The number of customers available to buy fish in an area can be compared with the value they attach to fish in that area.

   If in an area, 100 small scale tilapia farms (potential customers) are willing and capable of buying tilapia fingerlings at the price of ₦20 per fingerling, while in another area, 2 small tilapia farms (potential customers) are willing and capable of buying fish at the price of ₦30 per fingerling. It may be better to establish in the first area where there is a larger volume. Though smaller value and with higher competition. There seems to be a chance of a more stable market and accessible.

2. Target Market is the group of potential customers a company want to sell its products or services. So, no one can effectively target everyone; it is wise to target a niche market which enables small businesses to compete with large established ones.

3. Market Need Assessment: market need assessment deals with knowing why customers buy the product. If customers buy tilapia fingerlings because they grow fast, it may differ from if they buy tilapia fish because of the flavor, the price, health factors or resistance to disease.

4. Competition between companies selling similar products and services are daily occurrence in business. A quick way to do the market analysis is to compare your competitors with your business using a simple table containing some important drivers of demand (Table 2). This will give a reasonable view of businesses you are competing with and will enable you find your competitors' weaknesses which your company could use to better position itself in the market.

Table 2: Hypothetical Competitors' Analysis

Company	**1st competitor (Tilapia Mixed-sex Fingerlings)**	**2nd competitor (Tilapia Mono-sex Fingerlings)**	**3rd competitor (Tilapia Mono-sex Fingerlings)**	**My company Tilapia Mono-sex Fingerlings**
Revenues	₦ 100,000	₦ 150,000	₦ 700,000	₦120,000 (first year target)
Employees No.	5	2	7	4
Size	1farm sales	1 farm	1farm	1farm
Price	Low	High	Low	Average
Quality	Average	Low	Low	Superior
Delivery	Free	No	₦1000	Discounted

5. Barriers to Entry are obstacles or hindrances that make it difficult for a new company to enter an existing given market. Analysis of barriers will answer two main questions:

    i. What prevents new entrants from coming in and taking off a good percentage of your customers?

    ii. What makes you think you will be able to break the barriers and successfully enter the market?

There are many barriers to entry. Some of the barriers to fish seed production business are:

- Investment in fish seed production is capital intensive, therefore a barrier to many who would have entered the industry.
- Location/Geographical: the inability to secure a good or suitable location for fish seed production and other factors will determine a successful enterprise.
- Brand loyalty: consumers' attachment to existing fish seed producer or their products.
- Brand cost: a huge marketing cost is needed to get to a certain level of recognition.
- Economies of scale: existing fish seed producers benefiting from lower average cost due to scale (size) of production. Inputs can be acquired in bulk, resulting to a reduction in cost of production appreciably.
- Being 'the first mover': some company earns a strong position because they are the first to enter and dominate a market.
- Regulations: these are rules and guidelines made by governing bodies to control production activity or process. A fish seed producer is expected to comply to these regulations that may affect production activities. These regulations vary from one country to another.

6.6. Financial Analysis

Financial analysis is the evaluation of the viability, stability and profitability to merit investment into the business or project. It can be used to build a long-term plan to draw business activities. There are several methods of financial analysis. In this module, we shall use the following Cost-Benefits Analysis (CBA), Profit Margin and Return on Investment

(ROI) as shown in Table 3 with an example of tilapia (*Oreochromis andersonii*.) production in Zambia.

i. Cost-Benefits Analysis (CBA): is a process by which organizations can analyze decisions, systems or projects, or determine a value for intangibles. The model is built by identifying the benefits of an action as well as the associated costs and subtracting the costs from benefits. This is often used in capital budgeting to analyze the overall value of money for undertaking a new project. The CBA produces a ratio: Benefit-Cost Ratio (BCR) which is an indicator that shows the relationship between the relative costs and benefits of a proposed project. It can be expressed in monetary or qualitative terms.

The Cost-Benefit Analysis Process

A detailed or exhaustive list of all the costs and benefits associated with the project will be made. The costs involved in a CBA might include the following:

- Direct costs including direct labour involved on the farm, equipment and machineries, seed cost, feed cost and all form of farm inputs.
- Indirect costs are electricity, overhead costs from management, rent, utilities.

If a project has a BCR greater than 1.0, mean that benefits outweigh costs. This implies that the business is feasible and worth investing in. For example, a BCR of 1.20 means that for every dollar spent in costs there is a financial gain of US$20 cents more.

Net Present Value (NPV) is the difference in the sums of discounted benefits and discounted costs. A positive NPV means the project is feasible while a negative one means the project is not worth investing in and the business should not be considered.

The rule guiding the use of NPV or CBR:

1. *If separate, unrelated projects is being assessed, and the budget for funding the projects **is not** limited, use NPV or BCR.*
2. *If separate, unrelated projects is being assessed, and the budget for funding the projects **is** limited, the projects can be ranked with BCR. NPV should not be used*

For small to mid-level capital expenditures, businesses which have short to intermediate time to completion, an in-depth cost-benefit analysis may be dependable for a sensible decision making. For very large businesses with a long-term time horizon, a cost-benefit analysis allows for calculation of the present value of money through discounting. The BCR is computed as a ratio of discounted benefit stream divided by discounted stream of costs. Inflation is accounted for by deflating prices using price indices.

Table 3: Financial Analysis of Tilapia (*Oreochromis andersonii*) Fingerlings Production in Zambia

Quantity of Broodstock Stocked	Size of broodstock stocked(g	Mortality rate @ 1%	Qty Remaining after mortality	Cost of feed	Other production cost($)
2,694	200	27	2,667	1,481	4,523
Total Production cost					6,004

Items	Amount ($)
Average weight	2g
Expected Yield	350,000
Selling price/kg	$0.03
Revenue	10,500
Profit	4,496
Return on investment (ROI)	74.895063
Cost Benefit Analysis (CBA)	1.74895063

REVENUE AND PROFIT

Break down of feed grade and amount (BRANDED AND COMPOUNDED FEED) to produce 500,000 fingerlings.

Feed Grade	Brand name	Unit Price (Kg)	Unit price (Bag)	Bag size	Quantity of feed in Kg required	Total cost of Feed ($)
0.2mm	Novatek	$1.10	$3.30	3	99	109
0.5mm	Novatek	$1.10	$16.70	15	225	248
1.0mm	Novatek	$1.10	$16.70	15	375	413
4.0mm	Novatek(Broodstock)	$1.10	$16.70	25	647	712
						1481

Berakdown of other Production cost

Items	Amount ($)
Labour (14 staff	2,570
Water	453
Transport	500
Unexpected costs	1000
Total	4,523

ii. Profit Margin: is the amount by which revenue from sales exceeds cost in a business. There are four levels of profit margins: gross profit, operating profit, pre-tax profit, and net profit.

Profit Margin = Net Profit/Revenue

These are gross profit margin, operating profit margin, pre-tax profit margin, and net profit margin. A company takes in sales revenue, which pays direct costs of the products or services. The cost of the product or service is subtracted from sales revenue. What's left is gross margin. Advertising, the indirect cost is also subtracted. What is left is operating margin. Interest on debt and any unusual charges or inflows unrelated to the company's main business are subtracted with pre-tax margin left over. Taxes are paid, leaving the net margin, also known as net income, which is the very bottom line.

The Profit Margin:

- Measures the degree to which a company or a business activity makes money, by dividing income by revenues.
- Expressed as a percentage; indicates how much profit has been generated for each dollar of sale.
- Most significant and commonly used is net profit margin, a company's bottom line after all other expenses, including taxes and other costs have been removed from revenue.

- Used by creditors, investors, and businesses as indicators of a company's financial health, management's skill, and growth potential.

iii. Return on Investment (ROI): this is a financial metric of profitability that is used extensively to measure the profit or gain an investment can realize. The ROI is a simple ratio of the gain from an investment relative to its cost. It is as useful in evaluating the potential return from a stand-alone investment. It can also be used to compare returns from several investments.

Return on Investment can be positive or negative. A positive ROI figure means that net returns are good because total returns exceed total costs. A negative ROI figure means that the investment produces a loss because total costs exceed total returns. Computation of an accurate ROI requires inclusion of Total Returns and Total Costs. It is better to express ROI as percentage because it is easier to comprehend and make deductions from.

Steps in calculating ROI:

- Compute all costs and all income
- Sum all the costs to generate total cost of production
- Sum all income to generate total income
- To calculate net income: subtract total cost of production from the total income (total cost of production - total income)
- To calculate ROI, divide net income by total cost of production and multiplied 100 (net income/total cost of production x 100
- Knowledge of the factors to be considered in cost computing is important to prevent omissions.

iii. Return on Investment (ROI): is a financial metric of profitability that is used extensively to measure the profit or gain an investment can realize. The ROI is a simple ratio of the gain from an investment relative to its cost. It is as useful in evaluating the potential return from a stand-alone investment. It can also be used to compare returns from several investments.

The ROI can be positive or negative. A positive ROI figure means that net returns are good because total returns exceed total costs. On the other hand, negative ROI figure means that the investment produces a loss because total costs exceed total returns. To compute ROI with greater accuracy, total returns and total costs should be considered. It is better to express ROI as percentage because it is easier to comprehend and make deductions from.

Steps in calculating ROI

- Compute all costs and all income
- Sum all the costs to generate total cost of production
- Sum all income to generate total income
- To calculate net income, subtract total cost of production from the total income (total income- total cost of production)
- To calculate ROI, divide net income by total cost of production and multiplied 100 (net income/total cost of production x 100),
- Knowledge of the factors to be considered in cost computing is important to prevent omissions.

6.7. Sourcing for Capital/Grant

A capital-intensive project or business-like tilapia seed production is usually difficult to start. This is a barrier to entry. Hence ways of overcoming this challenge must be considered.

If business owners do not have the funds to start or improve an existing business, the other available options are seeking for a grant or getting a loan.

There are many ways to secure the funds required to complete a project:

1. Personal fundraising: the first investor in a business should be you. This can be in form of cash, in-kind or with collateral on assets. This signifies to potential investors that you have a long-term commitment for the project you are embarking on.
2. Partnerships: this is an agreement between two or more parties to advance their mutual interest (sharing management and profits). The partners may be individuals, Non-Governmental Organizations, businesses and Community-Based Organizations.

- Check if there are other organizations, either not-for-profit or commercial, that could partner with you in sharing the capital costs of the project.
- Depending on agreement and arrangement, they may join in management (sharing or dividing responsibilities) or they may be passive.
- It is advantageous when the partners are trained and equipped in different fields because it increases the chance of success.

3. Government or public funding: depends on the country and agricultural policies. There may be grants and subsidies by government for low interest loans expected to boost agricultural production. It will be good to check lists of available grants or loans by government either online or at governmental offices in charge of such funding.

***b.i. Leaning Activity*:**

Learning activity will be prepared that leads to discussion, remembering, memorizing, action on Module 6.

6b. ii. Facilitation Methods

Facilitation methods to be used by facilitators include:

v. Lecture with audio-visuals
vi. Brainstorming on issues raise
vii. Role plays on key issues
viii. Group discussion and feed backs in plenary

6b. iii. Learning Materials: (W*rite narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content). Sequential narration of module will be accomplished in simple non-technical form.*

***6b. iv. Output Evaluation with Feedback*:** *(Prepare evaluation questions based on the content/s you covered; either open- or close-ended). Then prepare answers for learners to check their performance.*

Output Evaluation with Feedback

1. Differentiate between loan and grant.

2. Is competition an advantage to fish feed business?

3. List advantages of branding.

4. What are barriers to entry?

5. List the safest forms of sourcing for fund.

6. What are the challenges of personal fund sourcing?

7. What is the advantage of partnership funding?

8. What is the disadvantage of partnership funding

9. Direct costs include the following except

(a) Seeds cost (b) Equipment and machineries (c) Feed cost (d) Rent

10. Indirect costs include except

(a) Seed cost (b) Overhead costs from management (c) Electricity (d) Rent

CONCLUSION

Tilapia farming is growing faster than expected in many countries especially in the developing world. It is likely to solve food security (aquatic chicken) as a cheap source of fish protein. Production of billions of high-quality fry is necessary and therefore the need for more quality brood stock.

KEY TERMS

Term	Meaning
Algae	These are photosynthetic organisms that possess photosynthetic pigments such as chlorophyll. However, they lack true roots, stems and leaves characteristic of vascular plants.
Artificial Breeding	A process in which some stimulants, hormones or pituitary extracts are injected in the broodstock (which do not spawn in captivity) thereby causing the fishes to spawn.
Better Management Practices (BMPS)	Any program, procedural technique, method-of-operations, skills, measurement or device that maximizes health and well-being of cultured species, minimizes environmental effects, and promotes an efficient and economic aquaculture operation.
Broodstock/Breeders	Broodstock or broodfish, are a group of mature individuals used in aquaculture for breeding purposes.
Cost-Benefits Analysis (CBA)	A process by which organizations can analyze decisions, systems or projects, or determine a value for intangibles
Cost-Benefit Ratio (CBR)	An indicator that shows the relationship between the relative costs and benefits of a proposed project.
Dissolved Oxygen	The amount of gaseous oxygen (O_2) dissolved in the water. Oxygen enters the water by direct absorption from

	the atmosphere, by rapid movement or as a waste product of plant photosynthesis. Dissolved oxygen levels below 5.0 mg/L can cause stress to aquatic life.
Feed Conversion Ratio (FCR)	Amount of feed required to grow a kilogram of fish; e. g. if two kilograms of feed is required to grow one kilogram of fish, the FCR would be two. This means that when a feed has a low FCR, it takes less feed to produce one kilogram of fish than it would if the FCR was higher. The lower the FCR, the better the feed performance and vice versa.
Fertilization	The fusion of haploid gametes, egg and sperm to form the diploid zygote. During spawning season, the male fish seek out the nests of fish eggs that the female has laid. When they find one, they swim over the nest, and fertilize them with their semen. This allows conception to take place, and immediately the fish eggs start to become fish.
Fingerlings	Fish eggs hatched into larvae develop into the size of fingers called fingerlings. Usually they are not older than 8 weeks
Fry	Freshly hatched fish not older than 4 weeks
Fungi	A group of living organisms classified in a unique kingdom. They are neither animals, plants, nor bacteria. Unlike bacteria, which have simple cells, fungi have complex cells like animals and plants.
Genetically Improved Farm Tilapia (GIFT)	Selective breeding to develop a faster-growing strain of Nile tilapia (*Oreochromis niloticus*) suitable for small-scale and commercial aquaculture for increased fish production.
Genital Papilla	A small, fleshy tube behind the anus in some fishes, from which the sperm or eggs are released

Gonad	A *gonad*, sex gland, or reproductive gland is a mixed gland that produces the gametes (sex cells) and sex hormones of an organism. In the female fish the reproductive cells are the egg cells, and in the male fish the reproductive cells are the sperm.
Gonadal Maturity	Both male and female fish gonads undergo marked cyclic morphological and histological changes before reaching full maturity and becoming ripe. This is called maturation of the gonads
Gravid	When fish are full of eggs which are laid and fertilized externally.
Hatchery	A physical structure, indoor or outdoor that is built for fish reproduction process. Hatchery provide sanctuary for fish seeds production and rearing before transfer to nursery ponds or sold off.
Hatchlings/Larvae	Freshly hatched fish not older than 5days. Fish larvae eat smaller plankton, while fish eggs carry their own food supply. Both eggs and larvae are eaten by larger animals.
Hormone	A regulatory (chemical) substance produced in an organism and transported in tissue fluids such as blood or sap to stimulate specific cells or tissues into action. Hormones may be natural e.g. African catfish pituitary or synthetic e.g. Ovaprim
Hybridization	The mating of genetically differentiated fish species either as individuals or groups and may involve crossing individuals within a species (also known as line crossing or strain crossing) or crossing individuals between separate species.
Incubation of fish eggs	The maintenance of fertilized fish eggs in a body of water or in fish-breeding (incubation) apparatus until the fry hatch. The fertilized eggs are incubated in a body of water (non-plant method) or in fish-breeding plants (plant method).

Incubation Trough	Containers used for hatching fish eggs in the hatchery
Juveniles	Hatched fish not older than 12 weeks; typically, between 25 and 50 mm long
Mono- Sex	Same sex population of fish
Optimum Temperature	The temperature at which a procedure is best carried out, such as the culture of a given organism or the action of an enzyme.
Ovulation	The release of eggs from the ovary
Parasites	These are disease causing organism in fisheries and these roundworms (nematodes), flatworms or flukes (trematodes) and tapeworms (cestodes); they are of public health importance;
Pathogens	Pathogens are infectious agents that cause fish disease. They are always present in an aquaculture system, but not always at sufficient levels to produce a disease.
pH	Power or potential of hydrogen ranging from 1 (highly acidic) to14 (highly alkaline)

Physio-Chemical Parameters	Consist of parameters such as water temperature, pH, dissolved oxygen, conductivity, salinity, secchi disc depth, nitrate, nitrite, sulfate, chloride, total hardness, calcium and magnesium which are measures of water quality.
Pituitary Gland	The major endocrine gland, a pea-sized body attached to the base of the brain that is important in controlling growth and development and the functioning of the other endocrine glands.
Productivity	Total fish biomass in a production system
Profit Margin	The amount by which revenue from sales exceeds costs in a business
Prophylactic Treatment	A prophylactic is a medication or a treatmen**t** designed and used to prevent a disease from occurring.

Return on Investment (ROI)	A performance measure used to evaluate the efficiency of an investment or compare the efficiency of a number of different investments. Calculate ROI: benefit (or return) of an investment is divided by cost of the investment.
Saline Solution	A mixture of salt and water. Normal saline solution contains 0.9 percent sodium chloride (salt), which is similar to the sodium concentration in blood and tears. Saline solution is usually called normal saline
Sex Reversal	In tilapia, sex reversal involves the treatment/administration of male steroid to recently hatched fry so that the undifferentiated gonadal tissue of generic female develops testicular tissue, thus functioning reproductively as males.
Sexual Dimorphism	Sexual dimorphism is the condition where two sexes of the same species exhibit different characteristics beyond the differences in their sexual organs.
Siphoning	Draw off or convey water by means of a tube in hatchery operation. This can be done manually (mouth-siphoning) or mechanically (pressure tube operation).
Spawning	The deposition of eggs and sperm so that they can unite.
Stock	Fish stocks are subpopulations of a particular species of fish.
Stocking Density	The number of fish that are kept on a given unit of area. In a monoculture pond, the stocking rate is the same as the stocking density because there is only one kind of fish.
Stunted Growth	Reduced growth rate. They constitute between 18-22% of freshly hatched fish population and should be sorted and disposed.
Water Quality Management	This includes the systematic collection of physical, chemical and biological information, analysis, interpretation and reporting of those measurements in comparison with the expected for maximum fish yield in aquaculture.

Wild/Natural Water Bodies	Naturally occurring waterbodies such as rivers, streams, lakes, lagoons and others.
Yolk- Sac	A membranous sac containing yolk attached to the embryos of reptiles and birds and the larvae of some fishes.
Zooplankton	Microscopic animal organisms drifting in oceans, seas, and bodies of fresh water.

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ADDITIONAL RESOURCES-FURTHER READING

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