KAPASA MAKASA UNIVERSITY

AQUACULTURE PRACTICAL MANUAL

DEPARTMENT OF AGRICULTURE AND AQUATIC SCIENCES

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PREPARATION OF THIS DOCUMENT

While fish farming based on a collection of broodstock from the wild for fingerling production and grow–out has probably taken place for many years, hatchery production with advanced techniques of Tilapia and Catfishes is a relatively recent innovation, with most research and development taking place over the last few decades.

This manual with eight (8) parts attempts to showcase the current wisdom on tilapia farming from different regions of Zambia and other countries where research and development, significant industry development, and extension of technology have occurred in recent years.

The development of this manual reflects contributions from all major organizations and research teams involved in tilapia culture development. Attendance at numerous workshops and conferences on tilapia fisheries and aquaculture over the past years has provided inspiration and insight into the need for a manual such as this, one that brings together the whole process of tilapia farming from broodstock to high-quality products leaving the farm.

This manual has benefited from so many farmers, researchers, fisheries and aquaculture professionals, business owners, information specialists, students, and technicians who have been kind enough to share their knowledge and skills, to name a few might devalue the contribution of others – so to you all, thank you.

To develop and meet the needs of the students taking Aquaculture and Fisheries courses at Kapasa Makasa University as the main beneficiaries of this manual.

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PART 1: SITE SELECTION FOR AQUACULTURE

Description of the Manual: This manual enable student acquires knowledge on how to better select sites before setting up an aquaculture facility.

Organization:

The section of the manual is a reading and hands-on practical step by step guide on site selection for aquaculture.

INTRODUCTION

Site selection is a very important exercise as it has a bearing on the future and profitability of the venture. There are several factors that one needs to consider before setting up the fish pond: topography, soil suitability, water quality, and quantity, seed availability, among others.

1. Topography

This entails the landscape, relief, and gradient of the slope. These have to be considered about water supply (into the pond and out). It is the ultimate desire of every farmer to minimize running costs/expenses; thereby maximizing profits. Cheaper means of channeling water thereby contribute towards cost reduction. A slope that allows water to flow naturally by gravity should be sought. For a flat land, pumps would have to be employed when either filling or draining ponds whereas in sloppy areas, the gradient can be used to utilize the force of gravity. However, a gently sloping ground (45% slope) is ideal as compared to steep slope. As for steep slopes, they should be avoided as they are prone to erosion. In uneven areas of rocks and many hills, maintenance costs will be high due to seepage and erosion. All big trees have to be completely uprooted as growing roots may cause pond seepage.

In swampy areas, one has to find out from past history flooding (from meteorology office, central statistics office, locals). For example, information such as the highest water level ever attained and lowest- to take precaution that ponds would not one day be submerged in water. Ideally, the pond bottom should be 50cm above highest water level ever attained.

2. Soil Suitability

Recommended soils are those that should be able to hold water without allowing it to seep away. It should be soils containing a great deal of living organisms (microbes) and organic matter; for earthen ponds, the ecosystem is very important as here, food availability is as a result of primary production which should be promoted. Clay soils are the best when it comes to ability to hold water- however, 100% clay is discouraged as it has tendency to crack when dry, and hence allowing extensive water loss. Therefore, loamy clay soils (75% clay) are advisable. It is expected that water would continue to be lost during the first 3 to 4 weeks of construction; but this is expected to seal/stabilize thereafter.

Caution:

- With clay soils, turbidity will be quite high and thereby hampering photosynthesis; clogging fish gills and eggs. Therefore, it is not advisable to stock the pond shortly after construction (give about 2-3 weeks for the water and soil to stabilize).
- Ferric soils should be avoided because the rusty particles tend to stick to the fish gills and later hamper respiration. Such particles may also stick to fish eggs and hamper respiration, causing the eggs to die out.
- Acidic soils are also not advisable as this tends to lower water pH; fish would be affected as they function normally under a pH of 6 to 8. Therefore, such soils should be neutralized by adding lime or ash.

3. Soil Survey

The objective of the survey is to obtain a representative profile of the general soil profile. Sampling of the entire area should be done, with a wide distribution of sampling points; these points should not be concentrated at one site alone- it should be randomized.

Three sampling methods are used; digging, drilling, and boring.

A. Digging/Open pit

- A pit is dug
- When water is found, continue digging for 2m and take note of the bottom soil
- When water is not found, one has to draw the soil profile as seen. The layers of the soil must be measured.

B. Drilling/Auger method

This requires drilling of the ground at the site. It is efficient and cheaper. Two types are used:

i. Bucket Auger: This is a metal cylinder (with a sharp bottom) that is drilled into the ground. The method is limitation as to how deep sampling can go since the bucket can only go to about 1m. Sandy, clay soils, and gravel are difficult to sample.

ii. Screw Auger: a screw type of blade is twisted into the ground and soil comes out in a spiral form. Sandy and clay soils are difficult to sample using this method. With this method, soil is severely disturbed and difficult to analyze.

C. Boring

This is done using thin-walled tubes which are hammered into the ground until they are filled with soil. It is relatively efficient as it gives an undisturbed sample. However, it is not effective in loose and very hard soils.

Soil Texture Analysis-Quick Field Testing

Soil texture is about the contents or particles within the soil sample. These particles will vary in size i.e. fine; coarse, etc. soil texture analysis can either be done in the laboratory or a quick field test. In the laboratory, the soil is thoroughly dried before being completely ground. Then it is sieved to get rid of stones, leaves, and any other form of debris; then a step by step procedure is followed to analyze the soil.

a) Throw the ball test

- Hold fine soil in the hand;
- Wet the soil;
- Mould the ball, making sure the ball is smooth and fine;
- Throw the ball in the air (about 50cm) and catch it;
- If the ball breaks apart, then the soil is not ideal for pond construction; not enough clay;
- If it remains intact, then the soil is good enough.

b) Squeeze the ball test

- Mould the soil into a ball just like in the test above;
- Squeeze the ball tightly in the palm;
- Open up the palm to release the ball;
- If the ball breaks up, the soil is not ideal; if it takes finger prints, then it is good quality.

c) Bottle Test

- This is done to find the actual proportion of soil particles in the sample; and the procedure is as follows:
- Put ground soil in a bottle/measuring cylinder;
- Add water to about ¾ volume;
- Stir well, don't shake the mixture vigorously;

After about an hour, layers of the soil are formed.

Upper layer =organic matter

Top layer = clay

Middle layer = silt

Bottom layer = sand

Note: Where layers are not homogenous, different samples should be taken from different points on the site.

Quick Permeability Test

- A pit 2m deep and about 50cm diameter is dug;
- It is filled with water to the bream and covered with tree branches;
- Covered to curb water loss through evaporation;
- It is left overnight and checked the next morning;
- It is highly expected that a greater amount of water (if not all) because the pores are open due to disturbance of the ground during digging;
- The pit is refilled with water, covered with branches and left over night;
- On the next day, the pit is checked and space left by lost water is measured; to get percentage of loss;
- The exercise is repeated for 3 to 4 times before a conclusion can be made.

Note: Soils that give retention percentage of less that 80% are not recommended.

QUALITIES OF SOIL

TEXTURE	PERMEABILITY	COMPRESSIBILITY	COMPACTING QUALITIES	SUITABILITY AS DYKE MATERIAL
Clay	Impermeable	medium	Fair to good	excellent
Sandy clay	Impermeable	low	good	good
Loam	Semi impermeable to permeable	high	Fair to very poor	fair
Sandy loam	Semi impermeable to permeable	Medium to high	Good to very poor	poor
sandy	Permeable	negligible	good	poor

4. Water Quantity

Water is a very important component to consider as it is the medium in which the fish is going to dwell. It is therefore the very first aspect to consider because without water, one can not grow fish; there is no substitute at all. The water availability should be in such a way that it is enough to last all through the entire growing period; enough to fill the pond at the start, and also sufficient reserve to turn to in case of topping up when water is lost through minimal seepage, evaporation, and in of replenishing due to dissolved oxygen scarcity. Water for rearing can either be from a natural source (river, stream) or pumped from underground (borehole). Whatever the source, there should be a reservoir set up deliberately to store water that can be relied upon in time of emergency.

Water Quality

The quality of water is the next item to consider upon being satisfied with the aspect of quantity. Water should be in such a way that it does not affect the fish negatively. Quality water is that which is free from pollutants such as heavy metals, non-degradable chemicals, high levels of organic matter, free of disease causing organisms etc.

Sources of water include river, ground water, rain water (funnels and filtering necessary before access into the pond)**,** dam water (not to be used directly as it is usually very cold and with less dissolved oxygen).

pH of the water is also a cardinal aspect to take note of. A pH of 6 to 8 is recommended in fish farming. Any deviation from the optimum (either lower or higher side) can be detrimental.

5. Seed Availability

Just like any livestock, or even crops, the kind of seed planted determines the output. Low quality seed yields a poor harvest while good quality seed produces high quality product. Fingerlings of the species that one plans to rear should be readily available; and the fingerlings should be good quality. Fingerlings must be sourced from a near distance as far off distances may not be ideal (fingerlings may get exhausted and die during long distance transportation-they are sensitive). For small scale farmers, it is ideal to grow herbivorous or omnivorous fish species. These are relatively cheaper to rear since their food chains a short and will not require supplementary feeds.

PART 2: POND CONSTRUCTION AND MAINTENANCE

Description of the Manual: This manual concentrated more earth ponds and it will enable students to acquire knowledge on how to better select before setting up a facility.

Organization:

The section of the manual is a reading and hands-on practical guide on fish pond construction.

INTRODUCTION

Pond Types

Basically three (3) types of fish ponds are recognized depending on dykes. The topography of an area determines the type of pond to construct, and these are:

Paddy Pond

They are built on relatively **flat land** and dykes are built on all four (4) sides to hold water. After excavation, the soil is used to build the dykes (top soil should not be used because quite loose and would allow seepage-contains a lot of organic matter).

Contour Pond

These are common in **gentle slopping** areas and dykes are built on three (3) sides only; the fourth side is a natural ground pillar.

Barrage Pond

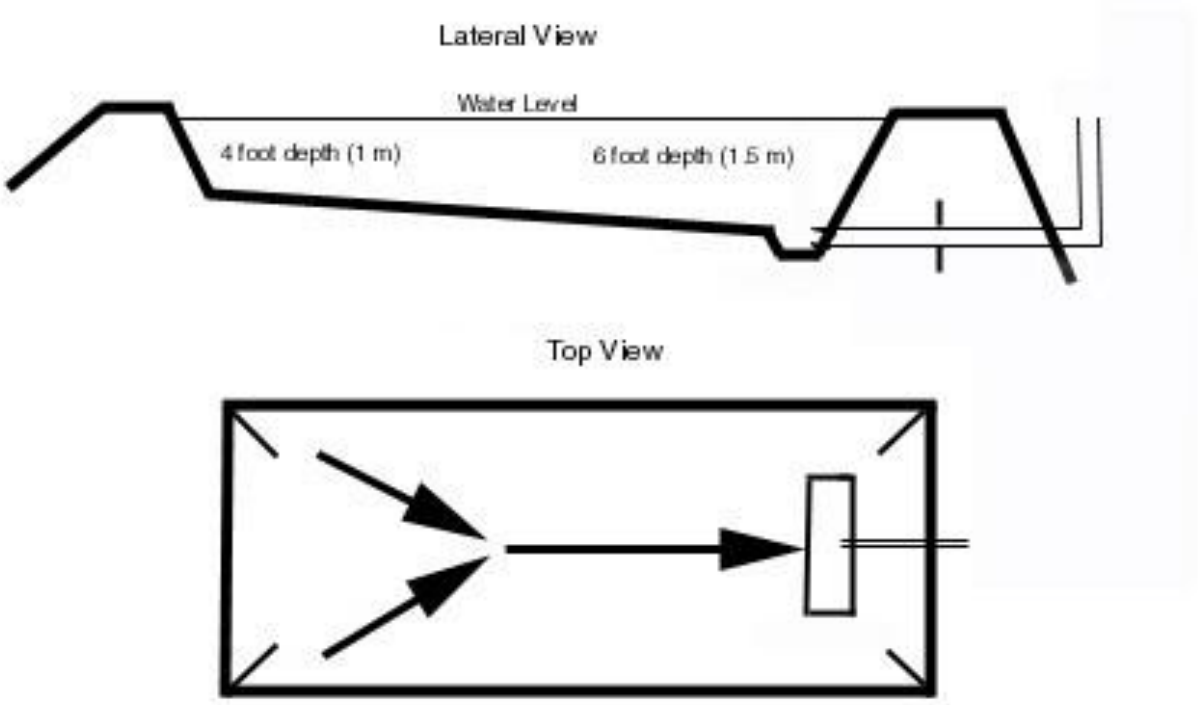
This is built in valleys by blocking a water body. Dykes are built across the stream to block water. It is quite sensitive in that one must have provision for controlling floods (spillway or dyke bypass to avoid dyke breaking). A screen should be put at the source of the canal and exit to curb wild fish entering the pond and exit of cultured species into the stream.

Steps in Pond Construction

- The first step to take is to clear the area of vegetation i.e. trees and grass. Big trees must be completely uprooted. Stones and any other objects should be removed as well;
- Clear a larger part than the size of pond that is to be constructed so that whatever dimensions are able to fit in the centre;
- All the top soil from the dimensions made should be removed and discarded far away i.e. 6 to 7m away. When subsoil is reached, you have to stop; unless there are roots still showing in that soil;
- Carry out pond demarcations; pegging;

- Dykes should not reduce the size of the measured dimensions. The top of the dyke and base should be 1m wide and 3m wide respectively;
- Dykes are constructed with slopping sides to make them hard and strong;
- Apart from the pegs set in the corners for demarcation, more pegs must be put in between the ends;
- Decide on the slope; use a spirit level to determine the slanting of the pond bottom;
- When building a dyke, there has to be a key trench incorporated in between the dyke;
- The key trench is then compacted with clay soil; serves in arresting seepage;
- The ideal time to construct ponds is when soils are just about moist (dry soils difficult to dig and wet soils wouldn't be compacted at all). Soil from the excavation is used in the building of dykes;
- After construction, pegs and strings used must be removed are discarded since they would rot and cause pores for seepage;
- When the pond is finished, grass carpet should be planted to curb erosion;
- Where possible, it is advisable to construct fish ponds in a rectangular shape (opposed to square) in the east-west orientation; this allows for maximization in the capture of light intensity.

All the fish ponds must ideally be of the same width (even if of varying surface areas) so that the farmer can only purchase and make use of one seine net.



FISH POND ACCESSORIES AND PARTS

An earthen fish pond is basically made up of dykes (pond walls); which hold the water to form the pond. It will have essential accessories such as the inflow canal, inlet, outlet, biological filter, sump/cropping pit, and the monk.

1. Inflow canal

Where the water source is not near the fish ponds, this canal is constructed to tap water from the source to the ponds (water source will include stream, rainwater, and borehole). Ideally, water from these sources should not be pumped directly into the pond; but allowed to first cure in a reservoir. This is because in some cases, the water temperature may be cooler than pond water, with a lot of debris, high in organic matter and nutrients, low in dissolved oxygen- and so allowed to stabilize in the reservoir or it would affect the cultured organisms drastically if pumped in the pond directly.

Water from the natural source may also contain wild fish and even disease causing organisms; hence screens should be constructed at the point that water leaves the source/reservoir and before it enters the pond. It is from the in-flow canal that water is channeled into the fish ponds; by way of separate canals/channels for each pond. This use

of individual inlet system is recommended to serve as a preventive measure so that in case of a disease outbreak or even algal bloom (or any other independent problem) in one pond, it is not allowed to spread to other ponds.

A water flow rate of 200-250L/s is needed if water is going to fill the pond in a shortest period of time; without compromising the well-being of the cultured organisms. The following quick formula can be used in calculating water flow rate (Q):

$Q = C \times V$

Where C= area (m^2)

V= velocity (m/s)

2. Inlet

This can be simple or complicated accessory; for instance, just a mere bamboo stick which can be plugged or unplugged as necessary. A complex inlet can have a valve (gate valve) or can be made of concrete. The inlet should be situated in the middle of the pond width, directly opposite the outlet point and should have a screen. The inlet canal should be on the shallow part of the pond, with the inlet way above the maximum water level to allow for maximum capture of atmospheric oxygen as the water hits the water surface, bubbles are formed. In the case of an earthen pond, stones/pebbles should be placed at the point where the water hits the ground to control soil erosion, hence providing aeration also.

3.Outlet

Just like the inlet, it can be simple (bamboo or small tube to plug and unplug as need be) or can be complicated. A complex outlet is incorporated with a monk; a structured constructed to regulated water levels; for instance, after a heavy down pour, one would expect the pond to over flow; risking a lot of fish losses- but the monk allows any water above the pond dyke level to flow over the monk, through the outlet, out of the pond, without fish loss. It is normally made of bricks, strong wood/planks, or concrete; and should have a very firm foundation. This monk should have the same height as the dykes, and as it works as an overflow. In the absence of a monk, a spillway can be constructed to get rid of excess

water. It is very important to put a screen at the outlet point to control fish escapes. The outlet is to be at the deepest end to allow for complete drainage.

4. Sump/Cropping pit

This is dug right in front of the monk (if it is present), or just right inside the simple outlet. Its function is that as the water levels are lowered (during harvesting), the fish moves away from places of lower water levels to the deeper end of the pond, into the sump; then this fish can be scooped easily i.e. makes through harvesting convenient. Occasionally, a deliberate effort should be taken to maintain and clean the sump; ridden of the silt that collects.

5. Biological Filter

The biological filter is meant to screen off what the physical filter (screen) is not able to arrest. Substances such as excess inorganic matter and disease causing organism can not be arrested by the physical screen; and may be detrimental to the cultured organisms. It can be constructed by arranging pebbles at the point the water leaves the main inflow canal to enter the pond. With time, algae and bacteria will begin to grow on the pebbles. The algae will assist in absorbing excess nutrients (so they won't find access into the pond and cause detrimental algal blooms), the pebbles will also arrest disease causing organisms. Occasionally, the pebbles have to be removed and thoroughly cleaned to get rid of the silt and other substances that collect over time; that may render it invalid. The ideal position for the filter is just before the inlet.

6. Dykes/pond walls

Dykes are the most important part of a fish pond, as they keep the necessary volume of water impounded and form the actual pond; their design and construction is particularly important. The walls should be firmly compacted and should be wide enough.

7.Characteristics of a Good Pond Dyke

A good pond dyke should have three basic qualities, which are:

a. It should be strong enough to be able to **resist the water pressure** resulting from

the pond water depth. To achieve this characteristic, a slope of 1:3 (30%) is recommended i.e. 1m dyke height to correspond to 3m of its width.

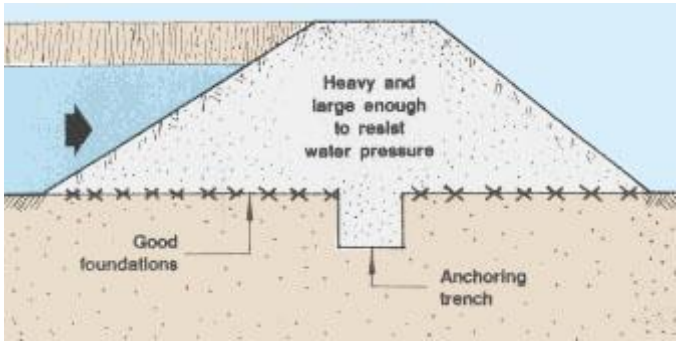
b. It should be **impervious**, to ensure that the water seepage through the dyke is kept to a minimum.

c. It should be **high enough** to keep the pond water from running over its top, which would rapidly destroy the dyke.

Resisting water pressure

Water pressure can be readily resisted by:

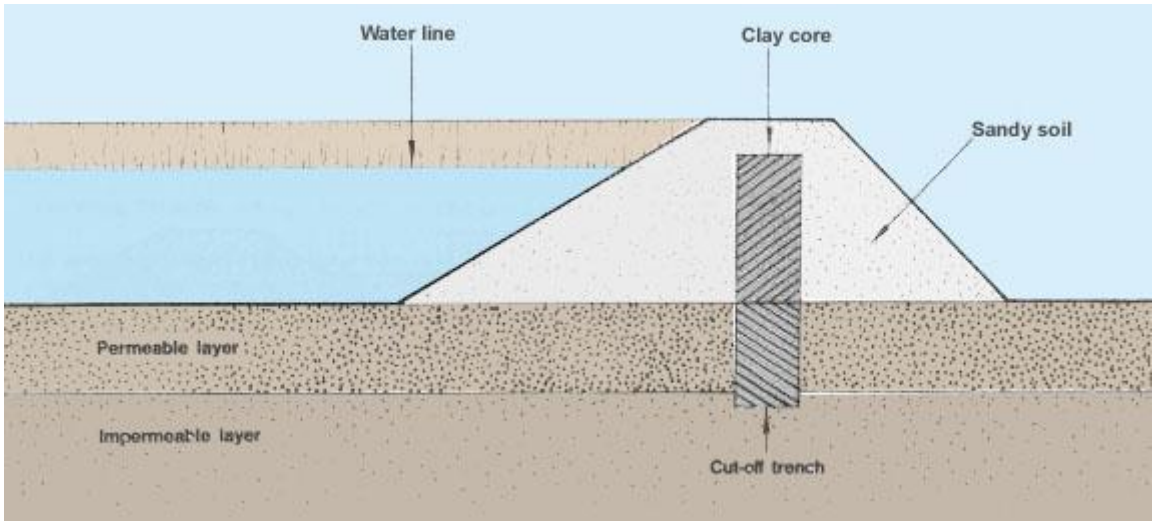
- **anchoring** your dyke strongly to its foundations (the soil on which you build it);
- constructing your dyke large enough to **resist the water pressure** by virtue of its weight.



Impermeability of the dyke can be ensured by:

- using good soil that contains enough clay;
- building a central **clayey core** when using pervious soil material;
- building a **cut-off trench** when the foundation is permeable;
- applying good construction practices;
- ensuring that the thickness of your dyke is appropriate.

Diagram of a pond dyke built using sandy soil with a clay core and cut-off trench to ensure impermeability



Size and Depth of Fish Ponds

Larger fish ponds are advisable as they provide a more stable environment than small ponds. Bigger ponds give e greater buffering capacity e.g. when there is a sudden change in water quality (rise or drop in temperature, low dissolved oxygen, pollution) and disease outbreaks; impacts of poor pond management are reduced. However, bigger ponds are problematic during harvesting, while smaller ponds emerge much more convenient to deal with.

Pond depth will slightly vary depending on the use; for instance, nursery ponds are much shallower (60cm to 100cm), whereas production ponds are deepest; 1 to 1.5m. The pond sizes will also vary depending on the intended use, with nursery ponds being the smallest (from $100m^2$ upwards) while production ponds are the largest ($1000m^2$ upwards).

PART 3: FISH FARM MANAGEMENT

Description of the Manual: This manual will enable students to acquire knowledge on how to manage fish farms for optimum fish production and productivity.

Organization:

The section of the manual is a reading and hands-on practical guide on best management practices.

INTRODUCTION

Fish Farm Management is the systematic way of carrying out management in fish production. This is guided by daily, weekly, and monthly routines. Some of the management aspects include:

- choosing and stocking fingerlings;
- ensuring good water quality conditions;
- providing the fish with adequate natural foods and feeds;
- Harvesting and marketing the fish.

Good management aims to obtain the best returns possible while observing the best aquaculture practices. It is important to make sure that ideal farm conditions are maintained and operations sustainable.

As the size and complexity of a fish farm increases, sound management based on technological knowledge becomes increasingly important. Good management aims to combine properly and operate effectively various production factors, such as land, ponds, fish, labor, and capital, to bring about maximum and continuous returns.

WHAT IS AQUACULTURE?

Aquaculture is commonly defined as the active cultivation (maintenance or production) of marine and freshwater aquatic organisms (plants and animals) under controlled conditions (http://www.epa.gov/agriculture/anaquidx.html, 2013). Aquaculture requires one to recreate the conditions in the wild for the plants and animals to grow well. In this case, we are going to focus on Fish farming which is the rearing of fish under a controlled environment to achieve the desired growth.

1. PRODUCTION SYSTEMS

Depending on the level of management especially feeding, fertilization, and liming, fish production systems can be classified as extensive, semi-intensive, intensive, and super intensive.

(i) Extensive Production System

This is a production system when the food base in a pond or reservoir is exclusively naturally occurring without supplementation. This system is popular among small scale producers who may be utilizing a reservoir that was mainly constructed for crop and animal irrigation purposes.

(ii) Semi-intensive Production System

In this system there is occasional supplementary feeding and natural food production is augmented with manures. Earthen ponds and concrete ponds are usually used in this system.

Concrete pond (Example of Semi Intensive System)

(iii) Intensive Production System

This system demands high level of management. Feeds and fertilizers are intensively applied following appropriate recommended rates. Suitable liming materials like agriculture lime are also applied to stimulate productivity and disinfect the pond of parasite and diseases. Fish grow very fast when intensively managed. Most commercial farms adopt this approach. Cages and tanks are the facilities used in this system.

*Cages on Lake Kariba (*Courtesy of Yalelo*)*

(iv) Super-Intensive Production System

This system demands the highest level of management. The culture environment is completely under control. An example of this system is:

a) Recirculation Aquaculture System (RAS) with bio-filtration tanks. Highest fish yield is obtained in this system.

Recirculation Aquaculture System (Example of Super-intensive Production System)

AQUACULTURE PRACTICES

(i) Monoculture

This is the practice of aquaculture where only one species is cultured in a pond e.g. under monoculture, a farmer may grow *Oreochromis andersonii* only in a pond.

(ii) Mono-sex Culture

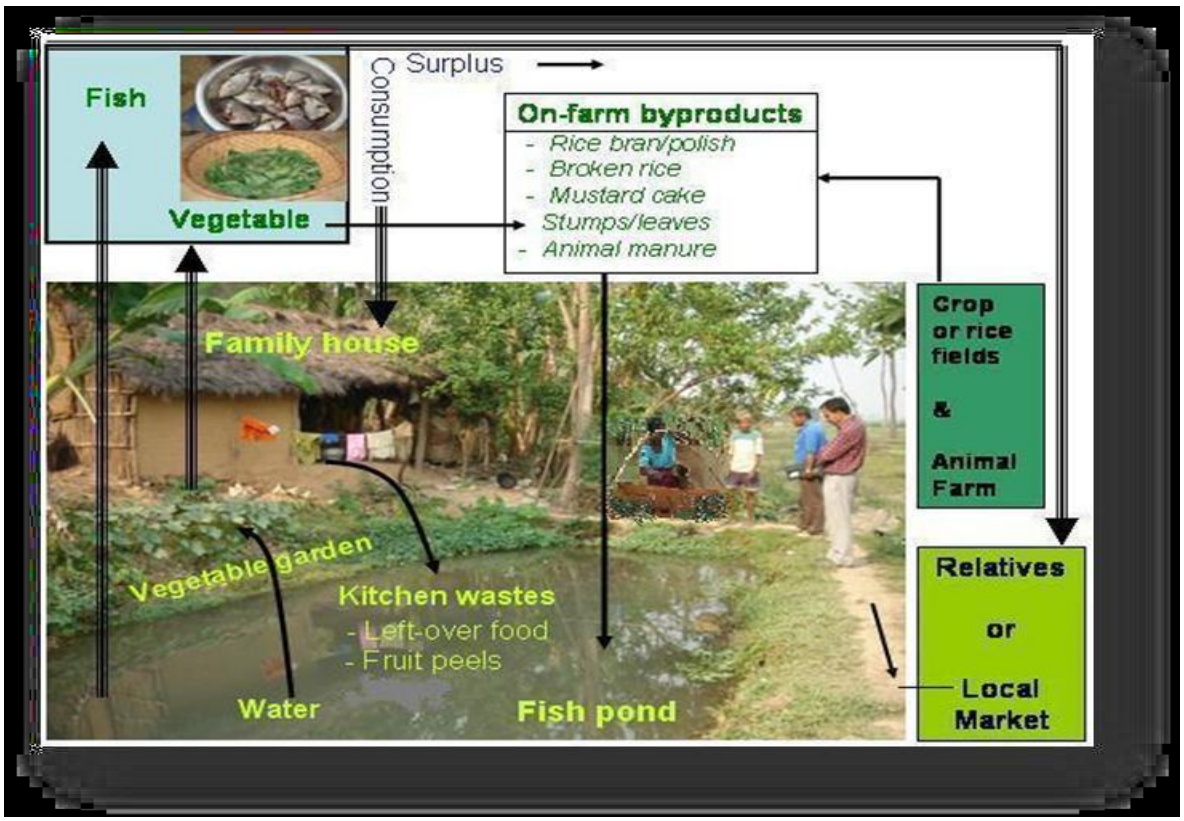
This is the growing of a single sex of a particular species e.g. male *Oreochromis macrochir* are preferred as they grow faster than female fish.

(iii) Poly-culture

This is the practice of culturing more than one species of fish in the same facility e.g. in a fish pond, *Oreochromis andersonii and Clarias gariepinus* can be cultured together and yields can be higher since foods in the pond are properly utilized because different fish species exploit food at different trophic levels.

(iv) Integration

This is a system where a farmer incorporates livestock and/or crops with fish. The idea is to have optimum utilization of farm by-products such as manure, kitchen wastes and vegetables which can be used to fertilize the ponds while water from the ponds can be used to water vegetables.



Integrated fish farming model

AQUACULTURE FACILITIES

These are facilities used to keep or culture fish either for ornamental or production purposes under controlled conditions. There are different types of aquaculture production facilities and the most common ones include Fish ponds, Cages, Tanks and Race ways. This module will focus on fish ponds and cages which are commonly used in Zambia.

1.1 FISH PONDS

Earthen ponds

A pond is an enclosure that is constructed to create the best environment and conditions for the growth of fish. A fish pond can either be earthen or concrete. Concrete ponds are sometimes referred to as tanks especially when they are small in size.

The following is the order of activities in earthen pond construction;

a. Site Selection

Proper site selection is recognized as the first step guaranteeing the eventual success of any aquaculture activity and therefore forms the basis for proper design, layout, construction and management of an aquaculture enterprise. For fish ponds, especially those to be used for aquaculture of high-value species like Tilapia, site selection is critical and should be given utmost attention.

The following are the commonly observed guidelines for the selection of a suitable site for fish ponds.

The major factors of interest are;

- Water quantity and quality
- Soil quality/type
- Topography (The site itself and slope of the land)

(i) Water quantity and quality

A perennial water source from a stream, spring and/or dambo is desirable for pond supply. The supply must warrant filling of ponds even in the dry season. Ponds will lose water through evaporation and seepage at the bottom or the dikes. Sufficient quantity of water is required throughout the production cycle. Quality of water on the other hand is an important element in fish farming although the physical and chemical parameters of water can be improved upon during management. It is recommended that water for fish ponds should be pollution-free and with a pH of 7.8 - 8.5.

(ii) Soil quality/type

The nature of soil influences water quality and more importantly water retention. A soil that holds water well must be preferred. For example, loamy clay must be chosen because of its better water retention capacity and suitability for dike making. Although clay may be the best soil to hold water, some type of clay are not good for pond construction because once dry they crack.

(iii) Topography

The topography of the site will determine the pond's form and size as well as the quantity of work required during construction. The site must have a gentle slope- a slope between 2 and 5 % is generally regarded ideal. The said slope facilitates gravitation flow of water from the abstraction point through the furrow into the fish ponds. This gradual drop of land also makes it easy to put up derivative ponds that can easily drain. This becomes practically convenient during harvesting periods and therefore reduces partial harvests.

Other considerations like; accessibility to the site, security, labor, inputs and market availability may be worthwhile to consider.

When most factors for selecting of a site for a particular purpose are not met one may need to modify objectives in order to meet the characteristics of the sites available.

N.B. Every site is unique and ultimately one's financial ability may dictate the suitability and use of site

b. Fish Farm Layout

The layout of the pond system depends on the species for culture and on the size and shape of the area, which in turn determines the number and sizes of ponds and the position of the water canals and gates. A fish farm is considered properly planned if all the water control

structures, canals, and the different pond compartments mutually complement each other. A complete fish farm will therefore require having a breeding pond, nursery and grow-out ponds and, in some instances, transition ponds for intermediate-sized fish, all of which are properly proportioned and positioned within the farm.

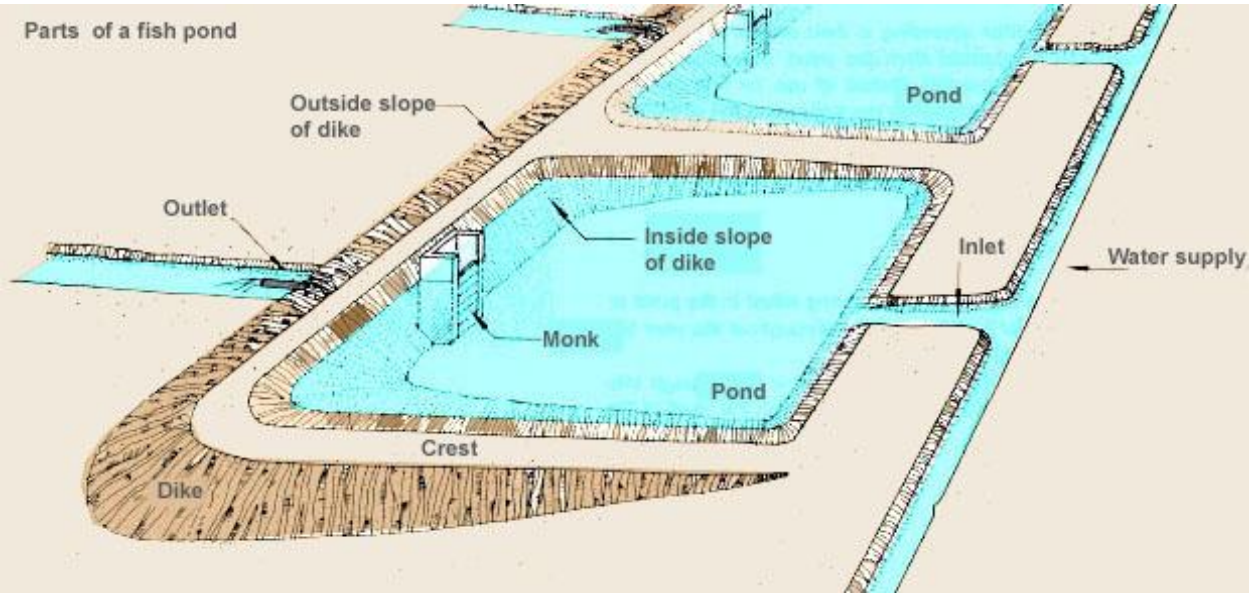
- Pond area should be visible from the House
- Nursery ponds placed between the spawning and production ponds
- Breeding ponds must allow for easy accessibility; fertilizer application, and easy transfer of harvested fish to storage ponds or the outside market.
- Avoid canals that have to run down a slope steeper than 5%.

c. Pond Design

Designing of ponds should be accompanied with a number of considerations in order to relate with the magnitude of the projected venture. Clear understanding of the type of fish farm you wish to build must be arrived at from the beginning. Other questions that may influence design include;

- Which level of production do I plan to reach?
- What production system shall I adopt (Intensive, Semi-intensive, Extensive, Super intensive)?
- Will I use fertilizers or fish feeds or both?
- Which fish species shall I produce?
- Will I integrate fish farming with other activities?

d. Parts of a fish pond



- ✓ The design of the dikes depends primarily on soil characteristics.
- ✓ Dikes may have a minimum of 1.5m apart.
- ✓ The slopes are characterized by 1:2 for exterior and 1:3 for interior side.
- ✓ The smaller the breeding pond, the easier and better the management practice.

e. Pond Construction

Pond Construction must be directed by the objective of creating an optimal environmental condition ideal for fish growth. Good site selection and pond demarcation will make pond construction much easier. Ultimately good pond construction will make pond management easier and prolong the life of the pond.

Different people have adopted different construction procedures. However the following order of activities may be followed;

- Determine the exact location for the pond.
- Prepare the site, by removing all organic materials from the surface of the site.
- Marking the pond and dikes with stakes
- Digging out the pond bottom
- Building the dikes
- Installing the inlet and outlet
- Protect the pond dikes by planting grass
- Fill the pond with water

- Fertilize the pond
- Stock the fish
- Fence the pond whenever possible

Ponds are usually built by a mix of excavation and embankment on a sloping ground. They are usually drainable and are fed by gravity.

The ponds can be constructed:

- ✓ Either on sloping ground as a cut & fill pond;
- ✓ Or on flat ground as a four dike embankment pond sometimes called a paddy pond.
- ✓ It is usually drainable through a drainage canal.
- ✓ Their shallowest side should be at least 1m deep to limit growth of aquatic plants
- ✓ At times deeper ponds are necessary especially in areas requiring water storage.

Pond pegging and Construction

1.2. Cages

A cage is a culturing facility consisting of a framed net open at the top and floating on the surface, or when completely enclosed, the cage is kept below the water surface by adjustable

buoyancy or suspension from the surface. Among intensive culture methods, cage culture is one by which the farmer can stock a large number of fish, control over feeding, minimize unwanted reproduction, harvest easily and obtain maximum profit from a unit area.

Site selection

Prior to the introduction of a cage into a water body, three major factors of a site have to be taken into account and these are: Water quality, Water depth and Water current

(i) Water quality

First of all temperature, dissolved oxygen, pH and ammonia content have to meet the requirement of that species of fish desired to be cultured. In addition to these parameters the total mineral content, different forms of N and P, free CO_2, fenol, oil and tar content should be measured as well.

The water should not contain poisonous materials for fish. The expected change in the water quality parameters due to uneaten feed, faeces and other metabolic wastes during the growing season have to be taken into account.

Suspended particles

Non-living particles

- Minerals such as silt and clay
- Organic materials such as detritus, dead organisms, humus

The composition of e.g. pond water changes continuously, depending on climatic and seasonal changes, and how a pond is used. It is the aim of good management to monitor and regulate the composition of water to yield the best conditions for fish.

(ii) Water depth

There should be a minimum of 2 meters clearance below the bottom of the cage in order to keep it away from the mud and sediment. Generally deeper water areas have to be used for placement of cages.

(iii) Water current

Although cage culture can be carried out successfully even in still water, a water current of 10-20 cm/sec has a good effect on the oxygen supply of fish, ensuring permanent water exchange between the water body inside and outside the cage.

Additionally, a water current helps to remove the solid wastes from the cage quickly. However a high water velocity of more than 40cm/sec. is disadvantageous for cage fish culture for the following reasons:

- a large part of the food can be washed away
- the fish is forced to swim causing energy waste
- the regular shape of the cage is deformed (the useful water volume is decreased by the current)

The prevailing wind has to be taken into account during site selection as well. It may have a good effect on the water exchange by generating surface water current, however if it is too strong the cages should be placed in a sheltered water area or have to be protected by breakwaters.

(iv) Cage design and Construction

There are two common types of cages; fixed and floating in circular (round) and rectangular shapes. Fixed cages are attached to the substrate, whereas floating cages are facilitated by floating devices like metal or plastic drums, Styrofoam or sealed PVC pipes. Fixed cages are suitable in shallow water while floating cages are suitable in deep waters. Cages are mostly constructed using metal frames or poly-pipe frames depending on the size. Cages made with bamboo frames and nylon nets are also popular among farmers though they do not last long; the expected life of bamboo is only up to 2-3 years in water. Cage size varies from 1 m^3 to 1,000 m^3, and rectangular shapes tend to be preferred. Round cages might be preferred in a place where water current is strong and there will be spaces between cages which facilitate air circulation. The cage should be covered with a net with lockable door to prevent fish loss from jumping and predation by birds.

The cage is also fitted with a mooring system to anchor it so that it does not sway with the current. The mooring system is normally a block of concrete.

(v) Setting up the cages

A fish cage must be set up where there is a gentle current, enough to allow for sufficient aeration but not too strong to destroy the cage. It must be set up so as to allow a distance of a minimum of 2 meters from the bottom. If it is possible more space should be left.

The stocking rate of fish ranges from 50-100 fish/m^3. The stocking rates in cages are higher because the flowing water reduces the concern of oxygen shortages that is seen in the ponds. Closely placed cages and large cages will require additional aeration because this kind of placement and size inhibits the free flow of water and consequently limits oxygen circulation and availability.

Procedures in setting a cage

The procedure of setting up a cage may differ depending on the design, size, type of the cage and even material used. The example below is a procedure of setting up a cage made out of the following materials: Bamboo pieces, Styrofoam blocks, Empty Drums, Nylon nets with a mesh size of 15 – 25 mm, Wood pieces, Plastic ropes and Iron nails

• The net is attached to the frame by binding it tightly.

• Weights are fixed and hung around the bottom of the net to stretch the net into a desired shape.

• The floating rafts with net cages can be set in one or two series to form a battery of cages for large-scale operation.

• A wooden or bamboo platform can be constructed along the series of rafts to allow feeding trolleys, sampling equipment/buckets and harvesting nets etc. to be carried.

• The rafts with net cages finally need to be anchored strongly to the shore or bottom.

Set cages

2. FACTORS AFFECTING FISH GROWTH

Introduction

Various factors affect fish growth, these include: Genetics, water quality parameters like temperature, pH, dissolved oxygen (DO), total ammonia, turbidity, conductivity and planktons. Other factors are stress and diseases, which act on the fish physiology.

Water quality

The characteristics of pond water depend both on the water that has been used to fill the pond and the characteristics of the soil. However, within the pond water, some major chemical processes may take place:

Respiration (plants and animals)

- Oxygen is consumed
- Carbon dioxide is produced

Photosynthesis (plants only)

- Whenever sufficient light is available, carbon dioxide is used for production of plant material, while oxygen gas is released from the plants.

  Some selected key water characteristics that are of particular importance for fish pond management are;

- Water temperature
- pH
- Dissolved oxygen
- Conductivity
- Total ammonia
- Alkalinity
- Carbon dioxide
- Biological Oxygen Demand
- Salinity

(i) Water temperature

The growth and activity of fish depend on its body temperature. The body temperature of fish may be about the same as water temperature and varies with it.

A relatively low temperature can affect fish by:

- reducing the growth of young and older fish
- slowing down the rate of compost material decomposition
- slowing down growth in phytoplankton thereby reducing natural food availability

Temperature requirement for cultured fish species

The optimum water temperature range for good growth of cultured fish species is 22^0C to 30°C for tilapia and between 28-32^{o}C for catfish.

Managing water temperature

- Proper pond design allows fish to move to optimal temperature zones (deeper ends and shallow ends)
- Filling water to required levels all the time
- Avoiding shade from trees around the ponds

(ii) pH (Hydrogen concentration)

Water may be acidic, alkaline or neutral. The measure of the alkalinity or acidity of water is expressed by its pH value. The pH ranges from 0-14

- pH 7 indicates that water is neutral
- Values lower than 7 indicate acidity
- Values greater than 7 indicate alkalinity.

Importance of pH to fish production in ponds

pH affects the availability of nutrients for plankton growth (bloom development)

Bacteria prefer neutral water. Decomposition of compost or manure requires active bacteria.

Nitrogen and Phosphorus are more soluble in water with a pH of 5. Thus, acid water is not something we want.

Causes of daily pH fluctuations in ponds

The original pH of water is affected by the pH of soil, decomposition of materials, filling of ponds with more water and respiration of living organisms in the pond.

The pH of pond water varies throughout the day mostly as a result of photosynthesis, and through the night through respiration.

- At sunrise, pH is lowest
- During the daytime, photosynthesis increases. Carbon dioxide is removed from the water causing the pH to increase.
- A peak pH is reached in late afternoon.
- At sunset, photosynthesis stops but respiration continues for the rest of the night.
- More and more carbon dioxide is added to the water at night and the pH continues to decrease. The pH is lowest at sunrise.
- The next day, cyclic fluctuation of pH starts again.

Correcting low pH

Add lime. E.g. (i)hydrated lime at 100g/m^2

(ii)Quick lime at 200g/m^2

(iii)Agriculture lime at 300g/m^2

(iii) Dissolved Oxygen (D.O)

Importance of dissolved oxygen

- It is essential for respiration in fish and other living organisms
- It is necessary for decomposition of organic matter

Sources of Oxygen in water

- Oxygen contained in air diffuses into pond water.
- Oxygen is also produced during photosynthesis. This is the major source of oxygen in pond water.

Oxygen requirements of cultured fish species

Dissolved oxygen content in pond water of more than *5mg/l* is required by Tilapia for normal growth.

Some practical field indicators of low dissolved oxygen in ponds are;

- Gasping of fish (especially early in the morning)
- Extreme death of fish if dissolved oxygen levels are very low
- Actual measurement of DO by using an appropriate DO meter

Methods of increasing dissolved oxygen content in pond water

- Refilling the pond with fresh water
- Stop adding fertilizer (organic & inorganic) to ponds when there is an indication of low dissolved oxygen content
- An aerator may be used to improve the amount of D.O in the water.

Sources of common turbidity in fishponds

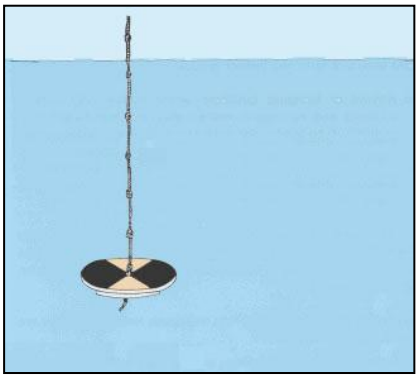
- Phytoplankton bloom
- Clay particles
- Rusty soil
- Runoff from rain water
- Fish behavior (Carp fish digging embankments)

How to measure turbidity in pond water

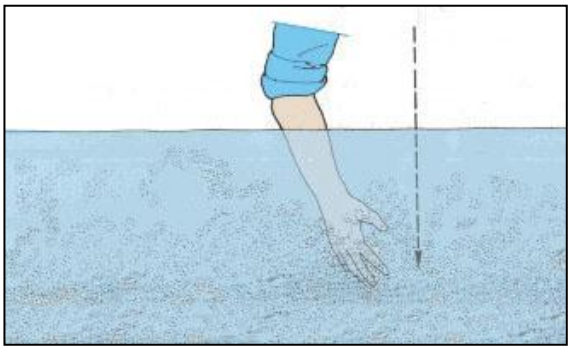
1. Use of Secchi disc

Measurement on Secchi disc	**Remarks**
Less than 20cm	Too turbid; too much plankton; Dissolved Oxygen low; or too much silt
20 – 30cm	Pond becoming too turbid
30 – 45cm	Pond in good condition (green)
45 – 60cm	Phytoplankton are scarce
60cm	Water is clear

2. Use of fingernails or palm – if the hand is dipped in a manured pond and the fingernails cannot be seen, it is a sign that the water is too green (too turbid); and if the fingernails can be seen, then the water is okey.



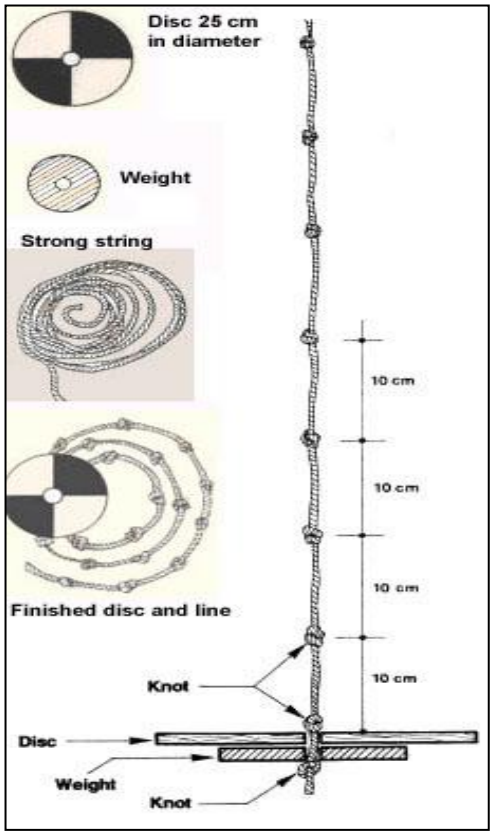
Secchi disc in pond water



Hand in pond water

Effects of suspended solids in pond water on fish

- Blocking the fish gills directly causing mortality
- Obstructing photosynthesis (the source of dissolved oxygen) to take place.



How to maintain optimum turbidity

- Optimal application of manure or compost
- Drain part of pond water and refill the pond
- Maintain good water level to avoid over-clouding of fish
- Plant grass on dikes of ponds to avoid erosion
- Use compost cribs for adding fertilizing materials to the pond
- Put a gravel filter in the inlet furrow in order to sieve the cloudy water.

3. Use of appropriate meter

Planktons

Planktons are microscopic living organisms and are in two forms. These are plant forms (phytoplankton) and animal forms (zooplankton). They are the natural food found in the pond. Their abundance greatly depends on water quality.

Fish Diseases

Occurrence of disease outbreaks in fish farming is due to bad husbandry since disease causing organisms are always in the environment and cause few problems until the fish are stressed through inadequate dietary or environmental conditions. Disease threats for an aquaculture facility vary with the type of production operation, its purpose, as well as the species or life stage being reared.

Poor handling of fish is one of the major causes of both parasitic and bacterial infections. Transporting of fingerling/fry from areas without proper care being taken can enhance spreading of diseases. Increased nutrient levels due to intensive culture promotes proliferation of parasites. pollution due to high levels of ammonia predisposes fish to succumb to large numbers of parasites. Human faeces maybe a source of gut parasites especially by common carp. Damages of fish by predators lead to a secondary bacterial or fungal infection .The predators especially birds and mammals play an important role in life cycles of parasites e.g. birds act as intermediate hosts in life cycle of the nematodes contracaecum and otters may act as final host

Common Diseases and Prevention

The impact from disease may occur as direct losses due to mortalities as well as indirect effects such as decreased production (reduced growth rates, feed convention efficiency or product quality) or loss of business or reputation.

i) Fungal infections
ii) Bacterial diseases
iii) Protozoan diseases
iv) Zoonotic diseases
v) Nutritional diseases

SYMPTOMS	PATHOGEN	PREVENTION/CONTROL
1.Cotton grey-white or brown patches on the skin	Fungus	-Good handling to avoid injury -Avoid handling fish in cold water -Low organic matter in water -Potassium permanganate ($KMnO_4$) 1 g per 100litres of water for 60 - 90 minutes Common salt – 10g per litre of water for 20 minutes for young fish and 25g per litre of water for Copper Sulphate ($CuSO_4$) – 5g per 10 litres of water till the fish shows the signs of stress Malachite green 67ppm for 10 -30 seconds. Note there are differences in opinion regarding the use of this chemical as it may cause genetic defects in fish and if not well handled it can cause organ damage, mutagenic, carcinogenic and developmental abnormalities.
2 Black Spots - Yellowish cysts on gills	Trematodes	-Control snails and discourage birds -Remove dead fish
3 Loss of appetite -Fin and tail rot -Pail gills -Fluid in abdomen	Bacteria	• Improve water quality/Avoidance of exposure to the disease • Use of disinfected water suppliers • Right stocking density • Maintenance of optimal temperature • Avoid over fertilization of the ponds • Copper Sulphate ($CuSO_4$) – bath for 20 minutes in 33ppm • Potassium permanganate ($KMnO_4$) – 2ppm for indefinite period of time • Immunostimulants such as soya bean protein, vitamin E and C.

		• Tobramycin – incorporated into the food 1g per 11.25kg of fish fed at 3% body weight/day.
4.Round worm in spiral shape near gills	Nematode (Contracaecum)	-Not really a problem but leads to consumer dissatisfaction
5.Fish try to scrap their bodies on hard surfaces (flashing)	Parasitic Protozoan	• Dips in salt, potassium permanganate or formalin • Keep temp near optimum range for that species of fish

Nutritional Diseases

Cause	Symptom	Prevention
1. Lack of protein	-Caudal fin erosion -Loss of appetite	Feed protein rich food e.g soyabeans, slaughter house by -products, fish meal
2. Lack of Lipids	-Poor growth	Feed with energy- rich foods

3. FARM MANAGEMENT

Pond preparation

There are four important steps in preparing a fish pond though the first step does not apply to newly constructed ponds:

Draining and drying: Ponds should be drained and dried for at least two weeks or until the pond cracks. Drying helps oxidize and breakdown chemicals and their residues in the mud,

and eradicates all wild fish, remaining fish from the last harvest, insects and other predators from the pond.

Liming:

There are three main purposes for liming ponds:

1) to increase the availability of nutrients,
2) to increase pH and to buffer against daily pH fluctuations and
3) to sterilize ponds prior to stocking.

Fertilization:

Adding of chemical fertilizers to the pond is necessary to enhance phytoplankton growth after filling the pond which is indicated by the green color of the water. Green water contains freshwater algae which are good sources of protein and several vitamins e.g. *Chlorella* and *Spirulina* 47.2% and 58.6% crude protein on dry matter basis. Chemical fertilizers such as urea and De-compost or Di-ammonium Phosphate (DAP) give green water rapidly. Urea contains 46% nitrogen (N) while DAP contains 22% phosphorus (P). Weekly application of 28 kg N and 14 kg P ha-1 which means about 60 kg of Urea and 125 kg DAP per ha is recommended. These fertilizers should be dissolved in water first in a bucket before spraying into the pond water. If not dissolved, fertilizers will sink and stay at the bottom, attached to the mud. Ponds need to be fertilized weekly after that, by the same fertilizers, at the same rate. However, depending upon the greenness of the pond water, the rate can be altered. If NPK (16-20-0) fertilizer is available e.g. Thailand, farmers may choose it as it has both N & P. Addition of 125 kg per ha (6 kg of per 500m2) per week will be sufficient to make water green. Animal manures (chicken manure) can also be used at the rate of 500 kg up to 2,000 kg ha/year depending upon the fertility of soil. However, animal manures have very low N and P concentrations. They are bulky and difficult to transport if they are to be procured from outside. Whereas chemical fertilizers are nutrient dense; therefore are easy to handle. They also create better water quality, thus ensuring higher survival of the newly stocked fish. The process will take about a week, after which time fish can be stocked.

Pond filling:

Before filling the pond, ponds and dykes need to be cleared out e.g. cut away pond grasses etc. Make sure that the source water is reliable and of good quality. Measurement and analysis of important water quality parameters such as calcium, pH etc. may be necessary. Before the water can be allowed to enter the pond, screens or sieves should be properly fixed on the inlet pipes, overflow pipes, and drainage pipes. This is done to prevent all forms of wild or foreign fish and their eggs from entering the pond.

Stocking for grow-out culture

The stocking rate depends on several factors, including fish species, level of management, facility type and size, and even the intended harvest size of the fish. To find the number of fish for stocking, calculate the pond area (The average depth in a fish pond is normally taken as 1m, which is why most stocking rate is referred to as fish/m^2) and multiply by the stocking rate.

Cage Stocking

The stocking rate of fish ranges from 50-100 fish/m^3 weighing between 15 to 20g because of the mesh size of the nets used. For example, when *Oreochromis niloticus* is used.

Pond Culture

Daily, weekly, and monthly pond management tasks

Daily

- Feed and observe the fish – are they eating? Are they still there? Are they growing? Are they sick? Are they reproducing?
- Check for signs of predators (foot prints, feaces, nests, pieces of eaten fish, etc).
- Remove frog eggs
- check predator traps
- Check the water level and add water if necessary
- Check for leaks, i.e., damp spots on the backs of dikes
- Check and clean pipes and screens
- Check canals and the main dam for blockages
- Take records of activities

Weekly

- Fill compost with plant material or manure

Monthly

- Cut grass on dikes. Dry and burn the grass and add the ashes to the pond
- Remove grass and weeds from inside the pond
- Monthly sampling

Cage Culture management practices

- Feeding fish according to fish demand
- Check for holes in the holding net
- Check the predator net
- Check for mortalities and remove the dead fish
- Check for water quality parameters
- Check for disease occurrences
- Monthly sampling

a. Fish predators and theft

It is important to try to prevent theft and predation before it happens, and to deal with it seriously when it does.

(i) Types of predators in ponds

(i)Fish predators

Fish predators eat eggs, fry, fingerlings and adult fish

(ii) Animal predators

These eat both small and adult fish

Frogs – these are notorious and quite difficult to eradicate. They compete for fish food, dissolved oxygen, and eat fish eggs

Birds – eat small and big fish

Humans – eat a great deal of fish; can poison the fish in the pond; and can harvest the whole pond without feeling pity for the owner

Snakes – eat eggs and fry

Control methods

- Ensure that screens are fitted correctly on inlet and overflow.
- Clearing by slashing around the ponds
- Setting traps and use of bird nets
- Having homestead near the fish pond
- Making scarecrows
- Avoid making perching near the fish culture facility

h. Fish harvesting in ponds

Harvesting is done at the end of the defined production cycle.

Harvesting fish using a seine net (Courtesy of Solwezi Aquaculture Research Statin)

Harvesting methods

- Seine netting,
- cast netting
- Hook and Line

Types of harvest

Partial harvest

This is the type of harvest which is done by simply lowering the water level and catching the wanted fish with a net or basket.

It may also be done when a farmer needs to harvest fingerlings only for a client before he or she is ready to harvest the adult fish.

This may also be done when a farmer wants to harvest a very productive pond in stages in order not to saturate the market.

Complete harvest

This is the type of harvesting where all the fish is caught from the pond upon draining it completely. Normally, if there are fingerlings, all the fingerlings are harvested first using a net or basket or pots before draining off all the water to avoid causing high mortality of the fingerlings. After all the fingerlings are removed, the pond is drained completely and all the adult fish harvested.

Holding pond

This is a small pond that is used for temporal keeping of fingerlings after harvesting. This is where farmers put their fingerlings to safeguard them while they prepare their ponds for restocking.

4.0 BEST AQUACULTURE PRACTISES

Introduction

In Zambia, aquaculture is regulated under appropriate statutory instruments relating to environmental protection and species use. Some of these regulatory instruments are the Fisheries Act 21 of 2011, the Zambia Environmental Management Agency (ZEMA) Act 12 of 2011 and the Water Management act 21 of 2011.

Aquaculture operators should adhere to the best management practices in order to minimize negative impacts on the environment.

Environmental Assessments

Depending on the level of the aquaculture facilities and management or type of operation, the following Environmental Assessments can be done:

- Environmental Project Brief (EPB) - For all cage culture operations. For pond culture of less than 100metric tones per year.
- Environmental Impact Assessment (EIA) - For all aquaculture projects of more than 100metric tonnes per year
- Strategic Environmental Assessment (SEA) - For all large areas and operators (not project specific) irrespective of the scale of operation.

Bio-security

Biosecurity involves the practices, procedures and policies used to prevent the introduction and spread of disease causing organisms like bacteria, viruses, fungi, parasites and other invasive species like rusty crayfish. Disease outbreaks happen rapidly and spread quickly, often resulting in high mortalities. Disease threat can vary with the types of production, purpose and the species or life stage being reared.

Food Safety

Fish that are ready for the market should be free of Salmonella and other disease-causing bacteria. No pesticides and other poisons should be used near the fish or aquaculture facility to avoid contamination and possible public health concerns.

PART 4: FISH SPECIES IDENTIFICATION AND SELECTION

Description of the manual

The identification of fish species is important to enable students to know how to select fish species for culture. Selection of fish species in aquaculture is also of prime importance. Some of the factors that should be considered in the selection include the biological characteristics of the fish, Potential environmental impacts, Social or religious concerns of the society, Impacts on other fishes or other living organisms, Input requirements for fish production, Marketability, and Ecological characteristics of fish species.

Organization

This section of the manual is a reading and hands-on practical guide on best management practices on the following:

- Practical will be conducted on Species identification
- Different fish samples will be prepared before actual identification and sexing, fresh samples will be placed in tanks in the hatchery
- Students will be able to Identification species of fishes.

INTRODUCTION

Fish species identification enables fish farmers to know exactly the fish species they intend to grow by observing their external features. There are many types of fish species found in aquaculture ponds. Not all fish species are suitable for aquaculture production. There are a lot of similar features that make people stock the wrong species. Fish species identification can be used as a planning tool, management tool as well as a marketing tool.

Several factors must be considered in selecting fish species for culture. Some of the critical factors include the biological characteristics of the fish itself, its potential environmental impact, social or religious concerns of the society, input requirements for its production, marketability, and ecological characteristics of different fish species.

Fish Species Identification

There are other types of fish found in ponds apart from the fish that the farmer may have selected to culture. Most fish have some common similarities in their features such that one may likely mistake the wild fish species to the cultured ones. It is therefore important to be able to identify some of the common fish species.

Figure 1: *Some of the fish species found in aquaculture facilities*

Furthermore, before the selection of fish for culture is done, one needs to know the typical features of each fish species and identify it. The descriptions below give the on - spot identification features.

Indigenous culturable fish species

i. *Oreochromis andersonii*

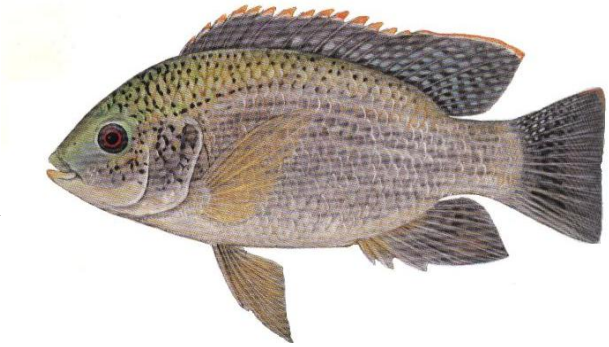
Common names

- Three spotted bream
- Kafue bream
- Njinji

Features

- Three black spots on the body
- Yellowish eyes
- Longer snout than *O. macrochir*
- Generally more slender than *O. macrochir* and *Tilapia rendalli*

ii. *Oreochromis macrochir*



Common names

- Green headed bream
- Pale, Kipale, Inkamba

Features

- Greenish head.
- Red eyes
- Orange tinged dorsal fin
- Mature males have tassel like genital papilla.
- Adults with black to dark brown spots and marks on the head region below the eye and on the gill cover.
- General body colour lighter or darker olive green

iii. *Tilapia rendalli*

Common names

- Red breasted bream
- Impende, Pende, Nkundu mbufu.

Features

- Reddish breast.
- Lower half of caudal fin reddish and upper grayish
- Clear Tilapia spot on the lower side of dorsal fin.
- Head is typically deep.
- Bright red throat.
- Body with 5-7 dark olive vertical bars.

iv. *Oreochromis tanganicae*

Common names

- Tanganyika bream
- Mpende

Features

- Scales of chest and belly very small but imbricating.
- Melanin pattern of body in facultative vertical bands of constant width, usually invisible in large preserved fishes.

v. *Clarias gariepinus*

Common names

- Barbell fish
- Cat fish
- Mulonge, Mulamba, Muta

Features

- Dorsal fin entirely of soft rays.
- Body strongly compressed towards caudal.
- Anal fin entirely of soft rays.
- Caudal fin is rounded,
- Head large and depressed, heavy boned.
- Eyes small, mouth large.
- Four pairs of long filamentous barbells

Exotic Culturable fish species

i. *Oreochromis niloticus*

Common names

- Nile bream
- Nile Tilapia
- Namadamu
- Wamunyima

Features

- Caudal fin has regular and prominent vertical stripes.
- 6- 7 dark vertical bars on body.
- Head profile (between *O. andersonii* and *T. rendalli*).
- Breeding males have red flush on lower jaw, chest and on margins of pectoral and caudal fins.
- Dorsal fin and anterior part of caudal fin is grey

ii. *Cyprinus carpio*

Common names

- Mirror carp
- Full scaled carp

Features

- Scales when present 35-39 in lateral line, 14 around caudal peduncle.
- Some strains have no scales if any very few and are called mirror carps
- Deep bodied with a long-based dorsal fin.
- Primarily ray of dorsal and anal fins are a bony serrated spine.
- Protruding mouth, with a single pair of barbells

Other fish species

i. *Tilapia sparrmanii*

Common name

- Katanga, Chituku

Features

- Colour usually deep olive green with 8 - 9 dark vertical bars on body.
- A well developed "tilapia spot" found in juveniles is also retained in adults.
- Caudal fin truncate.
- A dark spot on the gill cover.
- Breeding males have a bright red margin to the dorsal and caudal fin and a grey black throat and chest.

- Juveniles with characteristic light "bubbles" behind the tilapia mark on the soft dorsal fin.

ii. *Hemichromis elongatus*

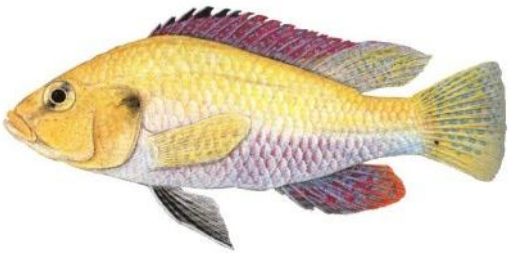
Common name

- Banded Jewelfish

Features

- Five black diamond shaped vertical bars along body.
- An oblique black band on the head passes through the eye.
- Upper gill cover with conspicuous red and black spots

iii. *Pseudocrenilabrus philander*



Common names

- Blue fish
- Trash fish
- Infindu, Chikolwa

Features

- The rounded caudal fin and orange tip to the anal fin.
- Oblique bar through the eye.
- Females are light brown with black vertical bars and light yellowish fins.
- Males look bluish.
- Does not grow big in ponds, remains more or less at a size of 6 - 10 cm

iv. *Serranochromis robustus*

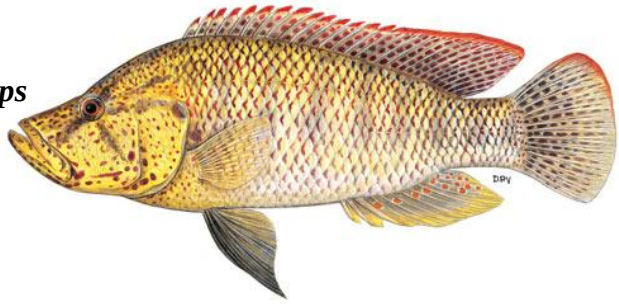
Common name

- Yellow belly
- Nsuku,
- Muliba
- Nembwe

Features

- Mouth large with large well-spaced conical teeth.
- Anal fins of males with orange egg-spots.
- Mature males develop deep yellow chest.
- A dark band along mid-body

v. *Serranochromis angusticeps*



Common names

- Large mouth
- Makobo,
- Polwe
- mbilya

Features

- Head and body with distinctive red spots on vermiculation.
- Very large mouth.
- Mature males have bright yellow heads.
- Caudal and dorsal fins are blue-grey with dark brown spots.

Table 4.1: Characteristics of different fish species

DENTITY	***Copotodon rendalli***	***Oreochromis macrochir***	***Oreochromis niloticus***	***Oreochromis andersonii***
	Red-breasted	**Green-headed**	**Nile bream**	**Three-spotted bream**
Appearance	Silver grey	Green-headed	Grey, striped (banded)	Blue-grey
Body	Typically deep	Deep dark olive green	Moderately deep	More slender than other breams
Head	Convex profile	Green with dark brown spots below the eye	straight or concave	Long snout
Eye	Red eye	Red eye differentiates it from *O. andersonii)*	Bright red eye	Yellow eye
Throat	Bright red	Grey-green		Black with grey
Chest	Bright red breast	Grey-green		Red during breeding
Bars	5 to 7 dark olive broad vertical bars	None	6 to 7 vertical bars	None
Spots	Clear Tilapia spot	Dark brown spots below the eye	Unclear Tilapia spot	3 to 4 mid lateral spots
Caudal fin	Lower half is reddish upper half is grey	grey with yellow margin	Grey stripes	Grey, red during breeding
Dorsal spines	14 to 16	15-17	Red when breeding (esp. males)	16 to 18
Dorsal soft rays	12 to 13	14 to 11	12 to 14	11 to 14
Lateral line scales	28-32	31 to 32	30 to 34	31 to 35
Anal spines	3	3	3	3

Adults	Length: 40 cm (20 cm in ponds)	on males: tassel-like genitals Length: 40 cm in ponds	breeding males have red flush on lower jaw and chest Length: 50 cm (25 cm in ponds)	Blue-black males with red-tinged fins Length : 50 cm (25 cm in ponds) (spots may not be visible on males)
Juveniles	Round head & beak like ,mouth few broad body bands, pelvics without pigment. Clear Tilapia Spot	8-9 thin vertical bars and yellowish fins	Clear bars across the body Clear Tilapia spot	Silvery with 8 to 9 irregular bars on body
Feeding	Omnivore but eats mainly plants	Omnivorous, although eats more detritus, algae and phytoplankton off bottom	Grazer: eats diatoms, algae and detrius, will also eat insects and small plants	Grazer: eats detritus, diatoms, zooplankton
Brood type	Substrate spawner	Mouth brooder	Mouth brooder	Mouth brooder

IDENTITY	***Tilapia sparmanii***	***Pseudocrenibrus philander***	***Hemicromis elongatus***
	Banded/Dwarf	**Southern Mouth Brooder**	**Banded Jewelfish**
Appearance	Deep olive green	Fmales light brown/ males light blue/yellow and red	brightly colored green and red
Body	Moderately deep	Stout	Robust with depth equal to head length
Head	Concave or straight	Straight	Oblique black band passes through eye
Eye	Red eye		large mouth
Throat	Grey black		
Chest	Grey black		

Bars	8 to 9 Dark vertical bars	Oblique bar through eyes, females have horizontal black bands on the body	5 black diamond shaped vertical bards on body, oblique black bar through eye
Spots	Dark spot on gill cover		red and black spots on gill cover
Caudal fin	Truncated, bright red margin		sooty olive
Dorsal spines	13 to 15	13-16	13-15
Dorsal soft rays	9 to 11 with Tilapia spot	9 to 11	
Lateral line scales	30 to 34	27-30	28-32
Anal spines	3	*7 to 9*	*3*
Adults	Breeding males have red margin from dorsal to caudal fin Length: 7-10 cm	Males have iridescent blue/yellow/red colors on body females are yellow with black bands length: 13 cm	Brightly coloured green and red Length: 19 cm
Juveniles	Light bubbles behind Tilapia spot		
Feeding	Omnivore, will eat eggs and small fry of fish	Preys on insects and the fry of other fish	Shrimp, insects, small fishes
Brood type	Substrate spawners.	Mouth brooder	Substrate spawner

IDENTITY	*Serranochromis robustus*	*Clarias gariepinus*	*Cyprinus carpio*
	Largemouth Bream	**Sharp-tooth Catfish**	**Common Carp**
Appearance	Olive to bright green	Grey brown with a white chest	Olive brown to gold
Body	Very Heavy-set and Robust	Strongly compressed towards caudal fin (flat, heavy head)	Very deep
Head		small, snake like eyes	Long snout
Eye	Large mouth	Large mouth with 4 pairs of barbells	
Throat		White or dark	
Chest	Deep yellow	White or dark	
Bars	A dark olive band along mid body	None	None
Spots	None	*None*	None
Caudal fin	Olive with an orange margin		Dark grey
Dorsal spines	15-16	Entirely soft rays	3
Dorsal soft rays	13-15		17-22
Lateral line scales	36-39	No scales	35 to 39
Anal spines	3	*Entirely soft rays*	2 to 3
Adults	Deep yellow chest length: 45 cm (25 cm in ponds)	Can reach 1.4 meters	*24 kg in ponds*
Juveniles	Without yellow chest		
Feeding	preys on fry and small fish	Omnivorous, will eat any organic feed	Omnivorous bottom feeder
Brood type	Mouth brooder	Substrate spawner	Lays eggs in shallow vegetation

Selection of fish species for culture.

In general, fish species are selected on the basis of fast growth so as to bring returns within a reasonable time. Furthermore, before choosing species for culture, a number of things have to be considered to help the farmers develop the confidence in the choice they are about to make. Farmers might be very disappointed if they chose a fish species just because they saw it perform better elsewhere. The following steps and considerations will be very helpful:

- Consumer preference
- Availability of the possible and preferred inputs
- Any questions or concerns about the species.
- Availability or the source of the species Seed or breeding stock

Factors to consider when selecting fish for culture

i. Biological characteristics

If the intention of the farmer is to grow fish to market size in a short period of time, then fish with high growth rates should be selected. Fish species which are able to thrive on natural feeds and artificial feed should be selected because they will grow within a limited season or period. The other important biological characteristics to be considered is to select species which are hardy and able to tolerate unfavorable culture conditions, e.g., low oxygen, pH fluctuations, low temperatures, etc. Selection should also take into consideration fish which are able to thrive and grow in dense populations in confinements which normally result into cannibalism, transmission of diseases, and accumulation of waste products.

ii. Potential environmental impacts

The introductions and transfers of fish species from one ecological area to another may have negative impacts on the native species in the receiving ecosystems in case of escapes. Therefore, fish selection for culture should be based on the fish species native within a certain locality.

Fish species which are invasive, cannibalistic or predatory must be cultured with a lot of precaution. For example, the invasive *Oreochromis niloticus* (Nile tilapia) can only be cultured under license in a secure aquaculture facility so that it does not escape into natural waters. Cannibalistic species like *Clarias* spp (Cat fishes) need constant grading during culture. A lot of precautions, therefore, must be looked at when selecting species with potential environmental impacts.

iii. Social or religious concerns

Social and religious concerns must also guide in the selection of species for culture. Farmers must select species to culture in their locality which are widely accepted for consumption in the same locality. In areas where religious beliefs forbid the consumption of certain fish species, for example, the eating of catfish among the Adventists, the selection of catfish for culture may not be the best option. The exception will be if the species are intended to be sold elsewhere.

iv. Input requirements for fish production

The cost and availability of inputs such as feed, fertilizers, seed and labour must be considered in the choice of species to culture. If, for example, the fish seed of a particular fish species of interest required by a farmer is not available within his locality, the input cost would go up if he had to obtain it from somewhere far. It would, therefore, be cheaper to grow fish from seed locally available.

v. Marketability

Availability of a ready market should also be considered whether it is a local or foreign. This will allow the farmer to realize desired profits from their fish farming business.

vi. Reproductive characteristics

Some of the reproductive characteristics of importance in the selection of species include;

- Inability to reach maturity early – most feed and energy are channeled to somatic growth. Farmers who intend to culture fish for production purposes should select such fish species e.g. studies have shown that *Oreochromis tanganicae* reaches maturity late compared to *Oreochromis niloticus* (Nkhoma and Musuka, 2014)
- In some cases, fish species that can reach maturity early and produce more eggs may be preferred for easier availability of eggs for the hatchery especially for farmers who are into seed production.

Criteria for selecting some culturable fish species

i. *Oreochromis andersonii*.

Advantages

- It is fairly fast growing fish that can bring returns within reasonable period
- It has no invasive traits and has been widely promoted for culture in Zambia.
- It can be cultured in most parts of Zambia such as the Zambezi, Kafue, and Luangwa watersheds.
- It is an omnivore that can feed on a variety of plant and animal materials including plankton
- It can perform in poly-culture systems with other fish.
- It can breed and has reasonable survival rate of fry even in the presence of other fish of prey.
- It is accepted across all religions and beliefs
- It has some considerable cold tolerance
- It has good taste and colour appearance
- It has the highest sex reversal rate using hormones compared to other tilapias (Kefi et al., 2014)

Disadvantages

- It is less susceptible to many common diseases and parasites

- Its sensitive when handled which results into mortalities

ii. ***Oreochromis macrochir***

Advantages

- It is fairly fast growing fish that can bring returns within reasonable period
- It has no invasive traits and has been widely promoted for culture in Zambia.
- It can be cultured in most parts of Zambia such as Zambezi, Kafue, Bangweulu, Chambishi, and Mweru watersheds without any environmental, social and religious concerns.
- It is an omnivore that can feed on a variety of plant and animal materials
- It is more specialized phytoplankton feeder (Jere et al., 2021)
- It can perform in poly-culture systems with other fish.
- It has very limited hybridization with *Oreochromis niloticus* or *Oreochromis andersonii* (Bbole et al., 2014)
- It has higher fecundity among the common *Oreochromis* species under culture
- It is less susceptible to many common diseases and parasites
- It has good taste
- It is less sensitive to handling compared to *O. andersonii*.

Disadvantages

- Growth rate is slightly lower compared to *Oreochromis andersonii*

iii. ***Coptodon rendalli***

Advantages

- It is a fairly fast-growing fish that can bring returns within a reasonable period
- It has no invasive traits and has been widely promoted for culture in Southern Africa (Jere et al., 2021)
- It can be cultured in most parts of Zambia without any social, environmental, or religious concerns.
- It is an omnivore that can feed on a variety of plant and animal materials
- It is a more specialized vegetative material feeder
- It does not hybridize with *Oreochromis species*
- It has the highest fecundity as a substrate spawner as compared to mouth-brooders
- It has a sharp most taste

Disadvantages

- It is a substrate spawner hence difficult to produce under hatchery conditions.
- It does not grow as fast as *O. macrochir*
- It is less susceptible to many common diseases and parasites

iv. Oreochromis niloticus

Advantages

- It is an exotic accepted for cage culture in designated areas of the country
- Has proven to bring economic returns with commercial feed
- It is fairly fast growing fish that can bring returns within reasonable period
- It is an omnivore that can feed on a variety of plant and animal materials
- It feeds on a variety of materials and easily changes feed types
- It can perform in poly-culture systems with other fish.
- It has fair fecundity with better fry survival rate

- It is relatively harder in handling than the indigenous species
- It is accepted across all religions and beliefs
- It is less susceptible to many common diseases and parasites
- It has fairly good taste

Disadvantages

- Its invasive (Jere et al., 2021)
- Its culture is restricted by legislation.

v. ***Cyprinus carpio***

Advantages

- It can be grown with other fish species (polyculture)
- It grows bigger and faster than tilapias.
- It's quite resistant to stress and diseases.
- It can easily grow on natural food (Plankton).

Disadvantages

- It does not breed easily in captivity
- Breeding of the species needs qualified personnel
- Fingerlings are not easily accessible

vi. ***Clarias gariepinus***

Advantages

- It's easy to process further in valuable fish products such as fillets
- It's not very sensitive to handling therefore it can growth in very harsh environments
- It can be used for control of population in tilapia culture
- It is resistant to most diseases and infections

Disadvantages

- It does not breed easily in captivity
- Breeding of the species needs qualified personnel
- Fingerlings are not easily accessible
- Marketing is a challenge because of consumer preference for mainly tilapia

PART 5: FINGERLING PRODUCTION

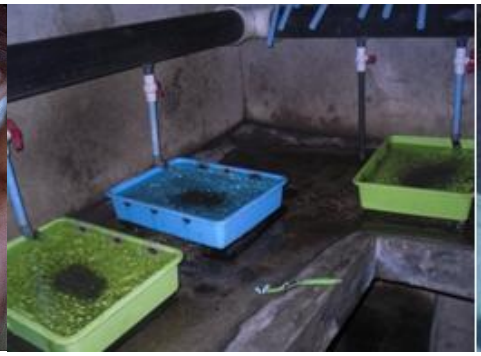
Description of the module

The identification of fish species is important to enable students have practical Kkknowledge on fingerling production techniques. Some of the factors that should be considered is proper broodstock selection and also biological characteristics of the fish, social or religious concerns of the society, impacts on other fishes or other living organisms, marketability and ecological characteristics.

Organization

The manual is a reading and hands-on practical guide on fingerling production on the following:

- Practical will be conducted on manual sexing brooders and hormone use to reverse the sex of fingerlings.


INTRODUCTION

Fish culture is an important component of many rural development projects in areas suffering from protein shortages. However, an adequate supply of fingerlings is not always available through established hatcheries. Farmers can produce their own fingerlings for sale or culture using one or more methods introduced in this module.

Basic Requirements for producing fingerlings

- Culture facilities require sufficient good quality water free of harmful chemicals
- All facilities should be cleaned and maintained on a routine basis. Hapas require periodic scrubs to remove organisms and debris which clog the netting and prevent water circulation
- Ponds and tanks should be built where they will not flood. Pond inlet and outlets should be screened to keep out predators.
- Ponds should be exposed to sunlight so that adequate transport can be produced as natural food.
- Ponds and tanks for commercial fingerling production should be completely drained and have catch basins.

1. FINGERLING PRODUCTION FACILITIES

Several facilities exists for fingerling production the common ones being netting enclosures called hapas, aquaria and tanks made of wood, fiberglass, metal, plastic or concrete are also used. Choice of facility will depend on species as well as available resources and the demand for fingerlings.

1.1 PONDS

Ponds can either be earthen, semi – concrete and concrete.

(i) Semi – concrete ponds

(ii) Earthen Ponds

These facilities can be used in several ways for fingerling production:

System 1: Single grow-out pond

This system is the simplest and requires only one pond. Fingerlings are stocked in the pond and cultured for a full production cycle. Some reproduction occurs during this time and at harvest the resulting fingerlings are restocked into the same pond for grow-out after the food fish are harvested. Fingerling holding facilities are required while the grow-out pond is being prepared for restocking. One production cycle ranges from 7 to 8 months. Numbers of fry and fingerlings produced in this system are low because of crowding and cannibalism. Commercial fingerling sales are not an objective.

System 2: Breeding pond

Commercial fingerling producers using this system employ a separate pond for reproduction. Brood fish averaging 100 g are stocked in this pond for spawning. Their fry grow into fingerlings weighing from 1 to 15 g. Continuous partial harvesting of fingerlings with nets of mesh sizes ranging from 6 to 12 mm, depending on fingerling size desired, begin 5 to 7 weeks after stocking the brood fish. Harvesting is done at 1 to 2 week intervals. Frys are transferred to other facilities for culture to larger sizes. The reproduction pond is drained, prepared and restocked with brood fish every 6 to 8 months. A one pond operation is possible. Fingerlings obtained from this system are more uniform in age and size than fingerlings produced using System 1. Partial harvesting results in increased fingerling production and growth due to reduced cannibalism and overcrowding.

System 3: Multiple ponds

The objective of this system is to produce 20 g male fingerlings in nursery ponds. The multiple pond system requires at least 2 ponds. A reproduction pond produces 1 to 2 g mixed-sex fingerlings which are harvested and stocked into a nursery pond for culture to approximately 20 g. They are then harvested and sorted by sex. Males are used in the mono sex culture where food fish of at least 200 g are preferred by the market. This system is designed for commercial operations with high fingerling requirements where control of reproduction in grow-out ponds is desirable, and for specialized markets where the additional expense of producing fast growing, all-male fish is justified. Two to three production cycles per year are possible.

1.2 HAPAS

Brood fish are stocked into net enclosures called "hapas" for reproduction. Fry are collected and transferred to other hapas, ponds or tanks for further culture into fingerlings or food fish. Complete removal of fry from the breeding hapa eliminates cannibalism by parent fish and siblings. Fry are concentrated in a small area so maximum recovery rates are achieved. Total fry production per unit area is much higher than previous systems. Hapas may be moved and set up in a variety of locations, but are especially well suited to lakes and ponds. Continuous production is possible.

Hapas set in pond

1.3 TANKS

Tank production of tilapia fry and fingerlings is practical where space for ponds is limited or expensive to develop. Cement tanks are common, but other materials, such as

fiberglass or plastic lined pools, may be used. Greater control over water management and routine maintenance is possible than with other systems. Fish may be easily collected with dip-nets or a small seine, and well-built tanks can last a lifetime. Continuous production is possible. Fry yields per unit area are higher than all the reproduction systems described except for net enclosures.

Concrete tanks

INCUBATION FACILITY

An incubation facility is a part of a hatchery system. A hatchery is a place of artificial breeding, hatching and rearing of fish through its early stages of life. A well-managed fish hatchery should be able to efficiently produce larval to juvenile fish for transfer to aquaculture facilities where they are grown to harvest size. There are two types of incubation facilities. Fixed and mobile incubation facilities

(i) Fixed indoor incubation facility ***(ii) mobile incubation facility***

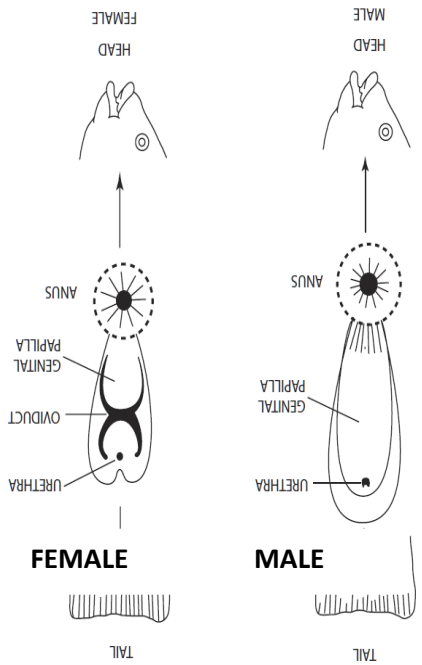
2. BROODSTOCK IDENTIFICATION AND SELECTION

Sex Identification and morphology of sex organs

Identification of males and females is done by looking at the genital papillae or the vent. Females have red and round vents with shorter papillae, while males have long and pointed papillae.

The genital papilla of male is larger than that of the females and has 2 openings; the urogenital opening, where the milt and Urine are excreted and the anus, for the discharge of fecal waste.

The female has a flatter and shorter papilla with 3 openings; the anus, the urethra (for excretion of urine) and the oviduct, where eggs pass through. Males have only one pore in the papilla from where the urine and sperms are released while females have two pores; one for releasing ova/eggs and another for urination



Male Female

(a) Sexual dimorphism

Traits in *Oreochromis* species are not the same. Sexual dimorphism is common in most *Oreochromis* species of tilapia. The males grow faster than females. It is reported that the males become 20 – 30% heavier in weight in comparison to the females

Characteristics of brooders

Maintaining pure, high-quality broodstoock is probably the core of successful fingerlings production. The selection of suitable brood fish will certainly have subsequent effects on the quality and quantity of the offspring produced. The following measures/characteristics should be considered in broodstock selection.

- **Purity of Broodfish**

  Broodfish should be genetically pure, and fish with unknown or questionable origins must be avoided.

- **Size of Broodfish**

  Broodfish should not be too small, because small fish are less fecund and less efficient at egg incubation and fry protection

- **Age of Broodfish**

  Broodfish must not be too old and must not have spawned several times, because fecundity decreases with maternal age and successive spawning.

  The selection of good quality broodstock is very important in order to get good quality fish seed.

  Good parents ⟶ Good eggs ⟶ Good seed (fingerlings)

3 BROODSTOCK STOCKING

Broodstock handling

Broodstock are very important fish which must spawn; therefore they must be handled carefully when they are being moved from one facility to another. The best size for broodstock is between 50 g and 150g.

- Use a hand net which has small mesh sizes. This is because big mesh sizes of nets tend to entangle the fish due to the fish spines. This may cause injury to the fish
- It is better to use anaesthesia for big brood fish to sedate the fish as it is moved to avoid injuries, excitement or bad simulation which may cause the fish not to spawn properly

Sexing, Separation and conditioning of broodstock

Sexing,

Sexing is the identification of the gender of the fish using their genital papilla as described above figure.

Separation

Separation is the segregation of males and females. The purpose of separation is for conditioning, or preparing them for breeding or stocking

Conditioning

This is the process that involves preparation of fish for breeding. During this period the fish must be provided with a 30% Crude Protein fish feed using an appropriate feeding regime.
There are several advantages of conditioning broodfish;

1. Conditioned males and females produce more eggs and fry
2. The spawning frequency is more than in non-conditioning or employing only conditioned females
3. Condition of fish results in the higher activity of rested males in courtship, compared to non-rested males.
4. The fertilization capacity of tilapia sperm decreases with increased mating frequency hence resting males will result in increase in tilapia sperm.
5. The replacing of old breeders with yearling breeders may also improve spawning efficiency.

It should however, be noted that frequent disturbances and conditioning of broodfish for long periods may lead to negative effects on reproduction efficiency. This may be as a result of re-absorption of ripe eggs in the ovary, which occurs after about a week if the females do not spawn. The quality of the fish sperm may also decline with resting for a long period, due to continuous production and release of spermatozoa into the lumen of the testes, leading to negative effects on the sperm quality.

Based on several research carried out on conditioning it is suggested that a month is long enough period for resting.

Broodstock stocking density and sex ratio

Maintaining the correct stocking density and sex ratio of farmed fish will certainly improve hatchery efficiency and mass production of fingerlings. Suboptimal broodstock density will result in low fingerling production. Also, high stocking density often reduces fingerling

production presumably due to aggression and fighting between males leading to reduction in courtship, egg fertilization and incubation (El-Sayed, 2006).
Several stocking densities have been suggested for optimum seed production e.g tilapia, depending on tilapia species, broodstock size and condition, culture systems and water quality. However, a stocking density of 4 fish/m^2 has been found to lead to better seed production and spawning synchrony in hapas suspended in fertilized ponds.

Equally extensive research has been conducted on sex ratio of tilapia broodstock because suboptimal ratio leads to reduction in seed production, waste of resources and an unnecessary increase in running costs. In Tilapias sex ratios of male: female are 1:1, 1:2, 1:3, 1:5 have been experimented with different results. However, a sex ratio of male: female of 1:2 and 1:3 have commonly been used with relatively better results. It is not common to stock more males than females in spawning units as this may led to aggression and fighting among the males which may cause severe harm to the females. However, for Carpfish the sex ratio is vice versa. Stocking needs more males than females e.g. 2:1 and 3:1 for synchronization purposes.

There is no clear cut sex ratio for efficient tilapia production. Therefore, the hatchery personnel must decide the appropriate sex ratio taking into account; the tilapia species, size and age, culture system and hatchery conditions. The optimum sex ratio may also be affected by the stocking density of broodstock.

4 Broodstock transportation

Factors to be considered during transportation

There are several factors that must be considered when transporting broodstock and fry. The ultimate goal is to provide healthy fish that survive after stocking.

Some of the factors to be considered include;

- **Water quality**

Water quality is an important factor to manage while fish are crowed and stressed in hauling. The major parameters that limit the loading density of fish are adequate oxygen levels and build up of toxic waste products like ammonia and carbon dioxide. Temperature, pH, loading density and trip duration affect severity of these problems.

A suitable water supply is needed for short-term holding and hauling. Cool, uncontaminated well water is preferred.

Pond water is less desirable because it often has a heavy algae bloom and other organisms that remove oxygen from the water and produce ammonia as a waste product. Pond water is also most likely to have harmful fish pathogens than well or spring water. Special care must be taken when using any surface water to make sure no harmful contaminants are present.

- **Fish Condition**

One critical factor to the successful handling and transport of fish is that fish be healthy and in good condition before they are hauled. Another important consideration is the variability of tolerance to loading and transport stress among species. Some species are very hardy while others require special precautions.

- **Water temperature**

Fish body temperature is almost the same as water temperature. When water temperature is becoming high, the fish body temperature is also becoming high and the fish needs more

oxygen. Therefore, the cold season is better than the hot season and early morning time better than day time which has lots of sunshine for fish transportation.

- **Hauling systems**

Fish can be transported in an open tub. This method is the cheapest and most simple but is not advisable for transporting fish especially broodfish. It is also not possible to transport large numbers of fish and over a long distance using this method. In this method one must be careful that the fish does not injure itself.

Another common method is the use of plastic packages. In this method polythene bags are used. Two plastic bags are used at a time. The plastic bags are filled with water quarter full and fish placed. Oxygen is supplied to the water using a gas cylinder and the inner bag tied. Then the outer bag is also tied separately and the plastic packages placed in a corrugated cardboard box and placed in the transportation vehicle. The density of fish in each bag depends on the size of the fish.

Aeration system

A variety of methods can be used to aerate water during transportation. Because fish are densely crowded and excited especially after loading it is essential to have an aeration system that provides adequate dissolved oxygen (DO) rapidly and efficiently. For most cases oxygen levels should be maintained at concentrations above 6 parts per million (ppm). Higher oxygen concentration near saturation may lessen the effects of any ammonia build-up, especially in long trips.

A hand pump or electrical pump can be used to supply oxygen to fish during transportation. Another method of aeration is using a compressed oxygen cylinder. This method is better than using a hand pump. Others use Liquid Oxygen (LOX) but whatever method is used one has to make sure that the fish is supplied with enough oxygen.

4.0 BROODSTOCK AND FINGERLING MANAGEMENT

Management of broodstock and fingerlings require maintaining several environmental factors at optimal levels. These include but not limited to water quality, stocking density and ratio, food and photoperiod.

Water Quality

Water quality is very vital in broodstock and fingerling management. Water quality includes all physical, chemical and biological factors that influence the beneficial use of water. There are many water quality variables in pond fish culture. The ideal water quality parameters for fresh water fishes are as follows;

Parameter	**Tilapia**	**Clarias**	**Carp**
Temperature(^{0}C)	22-28	22-27	20-25
DO (mg/l)	> 3	> 3	> 3.5
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Transparency (m)	0.5	0.2 – 0.5	0.5
NH_3 (mg/l)	< 4	< 8.9	< 13
Free CO_2 (mg/l)	50-100	40-45	-

Stocking density

The stocking density of fry is very important to consider. There is a negative correlation between the growth rates and stocking density of fry. Stocking densities of 3-5fry/m^2 is recommended especially in a hatchery facility.

The high stocking density of tilapia fry may also cause excessive cannibalism, leading to high mortality. Continuous grading of the fry in nursing units to separate large fry and using broodstock of approximately similar ages and sizes to produce eggs and fry of similar sizes are common practices to reduce cannibalism among tilapia fry.

Fry stocking

Stocking may be the most critical stage because fish are most likely to undergo some degree of stress during transportation prior to stocking. Different characteristics of water should be considered to avoid unnecessary shock.

Thermal acclimation is very important. Fish placed in water of different temperature may undergo thermal shock. pH acclimation is equally important.

Fry enumeration techniques

The counting of eggs, fry or adults is an important step in stocking. Enumeration methods should be accurate, practical and should not be stressful. The type of method to be used should depend on the species and size of the fish been stocked.

The following methods are used:

- Hand counting
- Counter
- Water displacement
- Visual comparison
- Weighing

In practical, especially when stocking small or fragile fish, length-weight tables may be used to get average weight. This is helpful especially in the field when scales available cannot weigh accurately these small fry being stocked.

Fry counting

Fry handling

The fry are still small and offer less resistance compared to the adults.

- They must be handled using a net with small mesh sizes.
- It is advisable to use a bucket to transport the fry from one facility to another
- It should be avoided to use hand nets.

5. SEX REVERSED FINGERLINGS

Male tilapia fish have been observed to grow faster than female tilapia fish. This is because the female fish tends to expend most of its energy to reproduction upon attaining sexual maturity. This is unlike the male tilapia fish which continues to grow even through sexual maturity. This justifies the growing need for all male tilapia culture which is likely to result into increased yields and profits from fish farming. Sex reversal is one of the ways in which all male sex populations can be achieved.

An androgen (male hormone) is used to promote muscle growth and the development of male sexual characteristics. An example of such an androgen is 17α -Methyl Testosterone. This hormone can be administered orally or through immersion or injection. However, the common method is oral administration. It is given to the fish by mixing it with feed. Since in tilapia the window period for sex change is between 14 to 21 days after fertilization the feed which is mixed with the hormone is fry mash (feed in powder form) with a recommended crude protein content of 40 -50 %.

PREPARATION OF SEX REVERSAL FEED

17α –methyl testosterone is mixed with feed at the rate of 60mg hormone/kg feed. Usually steroid hormone is dissolved in 30 ml of ethanol and mixed with 1 kg feed.

PROCEDURE FOR MIXING THE INGREDIENTS

- Prepare the already ground and sieved dry ingredients

- Mix the hormone-alcohol "stock" solution with the alcohol.

- Add the above solution slowly and mix with the dry ingredients.
- Allow the alcohol to evaporate at room temperature with no direct sunlight by spreading out the mixture to a maximum thickness of 3cm or less. Mix lightly by hand 2 or 3 times.

- Treated feeds can be packed once the mixture feels dry to the touch and all the odour of the alcohol has disappeared.

FEED STORAGE

- Do not keep feed materials or formulated feed longer than 21 days
- Feedstuffs undergo:
    - damage during storage due to rain, condensation,& high temp
    - damage during storage by insects (moths, weevils, beetles)
    - damage during storage by fungi e.g. Mycotoxins aflatoxins toxic to fish
- Sex reversal feed should be stored at 4^0C

FEEDING OF FRY

Fry are fed at 10% biomass for a period of 21 days. The minimum number of feeding frequency is four times per day, the higher the feeding frequency the better the feed consumption. Whatever the number of feeding frequency one takes, the time of feeding should be divided within the recommended period of feeding (between 08:00hrs and 16:00 hrs). Always use gloves to avoid direct contact with treated feed .After the 21 days of hormone administration, continue feeding with the normal fry booster feed and raise the fry to fingerling size between 5 and 15 grams. To ascertain the sex reversal success, Aceto camine gonadal squash method is used. By this stage, fingerlings are ready for supply.

6. ARTIFICIAL BREEDING

Reproduction in fishes is regulated by external environmental factors such as photoperiod; water temperature or water quality which triggers internal mechanisms into action. However, a number of fish species that have or potentially have great economic significance for aquaculture do not reproduce spontaneously in captivity. This may include species such as Catfish, Carp, and Labeo that may require placing in an appropriate environment or changing the fish's internal regulating factors with injected hormones hereby termed artificial reproduction to necessitate the final stage which is the release of eggs and sperm for fertilization. (Rottman R.W et al, 1991)

There are basically three forms of artificial breeding which include:

- Hormone injection: In this method, the male and female fish are placed in the same tank and left to spawn in the same way as in natural spawning after injection. This method could also be called semi- artificial breeding
- Stripping: This method refers to the act of pushing the eggs or milt out of fish that is ready to spawn (without hormone use) and thereafter mixing them in a dish to allow for fertilization.
- Hormone injection with stripping: This method requires injection with the hormone, allowing eggs and or milt to develop then stripping.

The method of choice depends on the fish species, hatchery facilities, experience and skill of the hatchery staff, and the desired manipulations of eggs, sperm or fertilized eggs.
(Rottman R.W et al, 1991)

Procedure for artificial breeding

- You will need to select the mature broodstock from the broodstock ponds
- Transfer them to the breeding tanks in the hatchery
- Prepare the spawning tanks by half filling them with water and placing them in the sterilized substrate
- Weigh the fish to determine how much the pituitary gland (hormone) will be needed to inject the fish.
- Extract pituitary gland from the donor fish provided

- Mix the crushed PG with 0.65% sodium chloride solution for carp fish and with 0.9% sodium chloride solution for cat fish
- Inject the females with hormone + salt solution at 3mg/kg of fish. If you don't have a scale that can weigh in milligrams, use donors weighing twice or more the weight of the recipient. When using purified hormone (aqua spawn) inject at 0.5ml/ kg of fish.
- For carp fish you do primary and secondary injections. Use 10% the dose for primary injection and 90% dose during secondary injection. The secondary injection is done after 7 – 8 hours. During secondary injection of females, inject also the males (100%) and place them in the same spawning tanks.
- It is advisable to use the sex ratio of **2 or 3 males to 1 female** for carp fish
- Inject the whole 100% dose for catfish
- Depending on the conditions (temperature) and the maturity of the fish, the eggs will have to be stripped from the female cat fish after 8 – 12 hours and put in the mixing bowl.
- The gonads in the male cat fish will have to be surgically removed, milt squeezed out and mixed with the stripped eggs
- The mixing of the eggs and milt will result into fertilization of eggs within seconds
- The fertilized eggs will then be gently spread onto the substrates in the spawning tanks
- Cover the tank with a black netting material in readiness for hatching after 3 – 4 days.

(i) ***Position of PG in Carp fish***

(ii) Extracted PG

PART 6: FISH FEED FORMULATION AND PRODUCTION

Description of the module

Fish feed formulation and Production is important to enable students have practical knowledge on fish feed production techniques. Some of the factors that should be considered is sources of feed ingredients, cost of feed, types of feed and Feed Conversion Ratios and also biological characteristics of the fish and feed environmental effect.

Organization

The manual is a reading and hands-on practical guide on fish feed formulation and production on the following:

- Practical will be conducted on sources of feed ingredients, diet formulation, mixing of ingredients, making feed and extrusion and storage of feed.

INTRODUCTION

Fish farming is now recognised as a viable and profitable enterprise worldwide. There is a push towards higher yields and faster growth involving the enhancement of natural food with prepared diets. Therefore, knowledge on fish nutrition and practical feeding of fish is essential for successful fish farming

1.0 NUTRITIONAL REQUIREMENTS OF FARMED FISH

Nutritive requirement of fish depends on the stage of growth of fish. Fish requires the following nutrients:

- Proteins for fast growth and body repairs
- Vitamins for good health
- Minerals for good growth
- Carbohydrates for energy

2.0 FEED INGREDIENTS

- Maize mea
- rice bran
- soya bean cake
- sunflower cake
- fish wastes

3.0 Feed ingredients and their proximate composition

Different feeds ingredients contain moisture, protein, carbohydrates, minerals & vitamins.Knowledge on their composition is of paramount. The following table tabulate the proximate analysis of some feed ingredients. .

Ingredient	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Ash (%)
Fish	**55 - 78**	**4 - 11**	**0.8 – 1.5**	**11 – 26**

Soyabean	**45 – 50**	**0.6 - 12**	**0.1 - 13**	**3.8 – 6.7**
Cotton seed	**45**	**1.6**	**13**	**7.1**
Wheat	**14 – 17**	**1 - 5**	**3 - 12**	**2 - 7**
Maize bran	**8 - 12**	**0.5 - 1**	**11**	**0.7 – 1.5**
Groundnut	**50 - 52**	**1 – 6**	**7 – 11**	**5 – 7**
Rice bran	**6 - 13**	**5 – 15**	**4 – 13**	**8 – 20**
Leucaena	**29.1**	**6.2**	**12.6**	**9.1**
Sunflower	**40**	**3.1**	**12.2**	**8.1**

4.0 FORMS OF FEED

Fish feed are produced in the following forms:

(a) Simple Mixtures

Meal form

(b) **Compound feed**

(i)Crumbles

(ii) Pellets

5.0 FEED FORMULATION METHOD

Formulation of fish feed at a local level depends on a number of **factors**. Each of them should be considered seriously for successful and sustainable fish feed formulation: After procurement of raw materials, feed formulation is essentialThe final proportion that it occupies in the formula must be **cost effective**.

The methods used are:

(i)Pearson square method

((i) winfeed

(ii) Least cost

(iv) Try and error

When formulating fish feed, one should consider the following factors:

(i) Identification of nutrient requirements for the fish species in question

E.g. fattening of bream fish:

Protein-18%, Energy-11%, Fat-10%, Minerals-4%,

(ii)Identification of locally available ingredients for their nutritive value

E.g. Available on the Copperbelt province – maize bran, soya bean cake, sunflower cake, cassava, etc

(ii) Selection of potential ingredients among the locally available ingredients

Important factors in feed formulation and production

- Availability or seasonality of the ingredients
- Unit cost of ingredients (price per kg)
- Processing procedure of that ingredient
- Anti-nutritional factors consideration
- Transportation costs of ingredients

6.0 TYPES OF EQUIPMENT MACHINERY FOR MAKING FEED

Grinders/Pouders/Hammer Mill

- Grinding helps in reducing the clumps, large fragments to desired size and, some moisture is removed

- Grinding of ingredients improves feed digestibility, acceptability and ensures uniform mixing

Mixer or Hands

- Feed mixing ensures a proper distribution of nutrients so that each small unit of the whole is the same proportion as the original formula
- For better mixing, mix small ingredients first and larger proportions last

Pelletizer or Hands

- Used for making fish feed pellets
- Almost complete uptake of fish feed is ensured by pelletizing feed

Weighing Scales

- For weighing ingredients and completed feed.

7.0 **PROCESSING OF FEED**

The selected ingredients must be processed in order to be applied to the fish. The equipment should make the following process possible:

- Drying
- Grinding
- Sieving
- Winnowing
- Packing
- Labelling.

Anti-nutritional factors decrease the availability of nutrients and so, affect the health of fish. Some examples are tabulated below.

CROP	**ANTI-NUTRITONAL FACTOR**	**PROPOSED REMEDY**
Cassava leaf meal	Linamarin	Local varieties have low levels
Cassava tuber	Linamarin cyanogen	Degradable by

		soacking,cooking
Soya beans	Aflatoxin trypsin inhibitor	Application of heat/boiling

8.0 **MAKING OF FISH FEED**

(a) Simple Mixtures – meal form

- Feed formed by mixing the powders of various ingredients
- Use of binders e.g. cassava meal.

(b) **Compound feed**

(i)Crumble making

- Mix the ingredients as the formula chosen
- Add cassava meal, flour or any other binder as a proportion of the ingredient
- Add water to the mixture
- Make sure every part is thoroughly wet
- Make flat chunks or paste dolls
- Spread them out in the sun to dry

(ii) Pellets

- Mix the ingredients as the formula chosen
- Add cassava meal, flour or any other binder as a proportion of the ingredient
- Add water to the mixture
- Make sure every part is thoroughly wet
- Use a pelletizer or an extruder to make either slow sinking pellets or floating pellets
- Dry the feed on direct sun light or dryer
- Pack the feed after drying

- Label the packed feed for easy identification

Preparation of Sex Reversal Feed

17α –methyl testosterone is mixed with feed at the rate of 60mg hormone/kg feed. Usually steroid hormone is dissolved in 30 ml of ethanol and mixed with 1 kg feed.

Procedure for mixing the ingredients

- Prepare the already ground and sieved dry ingredients
- Mix the hormone-alcohol "stock" solution with the alcohol.
- Add the above solution slowly and mix with the dry ingredients.
- Allow the alcohol to evaporate at room temperature with no direct sunlight by spreading out the mixture to a maximum thickness of 3cm or less. Mix lightly by hand 2 or 3 times.
- Treated feeds can be packed once the mixture feels dry to the touch and all the odour of the alcohol has disappeared.

9.0 APPROPRIATE STORAGE OF FISH FEEDS

- Do not keep feed materials or formulated feed longer than 21 days
- Feedstuffs undergo:
- damage during storage due to rain, condensation,& high temp
- damage during storage by insects (moths, weevils, beetles)
- damage during storage by fungi e.g. Mycotoxins aflatoxins toxic to fish

- Always put the feed on a palate or shelf.
- Sex reversal feed should be stored at Store at 4.^{0}C

10.0 FISH FEEDING PRACTICES AND TECHNIQUES

Better results are obtained when fish are fed correctly using the right techniques that ensure all fish have access to the feed, the fish's nutritional needs are being met and that no excess feed is fed. Feeding fish correctly means:

(i) giving feed of the correct nutritional quality for the specified age of fish,
(ii) feeding the right feed size for easy consumption,
(iii) feeding the correct amounts,
(iv) feeding at the right time(s) each day.

When fish are fed correctly,

(i) growth rates are good
(i) Uniform across the population,
(ii) FCRs are low
(I)Pond water quality is better managed.

Determining the amounts of feeds

When determining the amounts feeds to feed the fish, the average body weight is used at an appropriate feeding rate e.g. 10% for fry, 5% for fingerlings and 3 or 2% for adult fish but ***ad libtum*** would be appropriate .

It is advisable to reduce the amount of feed in winter as feed consumption by fish reduces.

There are several methods that are used when feeding the feed. These methods must be used efficiently to ensure maximum utilisation of feed. The methods include:

(i) Broadcasting
(ii) Use of feeding tables
(iii) Feeding rings
(iv) Automatic feeders.

11.0 **FEED ULTILISATION**

Feed evaluation is an important element which enables one determine the utilizations of feed with respect to growth of the fish. The food conversion ratio which is the amount of feed used in kg to raise I kg of fish is calculated after the harvest, and is calculated as;

- FCR/FCE
- FCR = Total amount fed(kg)/Total fish weight gain(kg)
- FCE = 1/FCR

Feed cost of production of the fish

- Unit cost of feed x FCR = Amount spent on the feed to produce each kg of fish

PART 7: FISH HANDLING AND MARKETING

Description of the module

Fish handling and Marketing is important to enable students have practical knowledge on fish handling techniques for marketing. Some of the factors that should be considered are handling procedures from harvesting to marketing, tools required, storage, packaging and transportation.

Organization

The manual is a reading and hands-on practical guide on fish handling and marketing.

- Practical will be conducted on best handling procedures, equipment, and storage, transportation and marketing strategy.

INTRODUCTION

To obtain premium prices on the market farmers should maintain high quality products by ensuring good handling practices. Good marketing practices are an integral part of any enterprise for it to be profitable. Market availability and accessibility stimulates production among farmers and ultimately increase their incomes. Producers should be well equipped with marketing information for them to make informed decisions (more information on informed decisions). A number of factors should be considered by the producer such as size, quality, species and freshness to meet market requirements or standards for him/her to be profitable. Therefore this manual seeks to equip students with knowledge and skills on fish handling and marketing techniques.

1. FISH HANDLING

SOURCES OF CONTAMINATION OF FISH

Sources of contamination

(i) From the food itself

(ii) Dust

(iii) Dirty

(iv) Debris associated with the food

(v) From personnel handling the food

(vi) Insects (less extent)

6.2 *Common failings in personal hygiene:*

(i) Failure to wear clean, protective clothing

(ii) Failure to cover wounds or cuts

(iii) Failure to wash hands after going to the toilet

(iv) Failure to wash hands before handling fish

(v) Spitting

(vi) Coughing/sneezing

(vii) Allowing finger nails to grow long

(viii) Smoking

(ix) Eating or drinking when handling fish

(x) Handling fish when you are sick (diarrhoea, vomiting, dysentery, skin infections)

(xi) Not washing hands after visiting the toilet

MARKET INFRASTRUCTURES

Design aspects (Buildings, Working surfaces, Sanitation, Equipment, Cleaning and Disinfection, Choosing a cleaning routine, Cleaning methods)

Design aspects

When fresh fish products are sold, it is particularly important to have a well designed facility and product-flow which will help prevent any form of cross-contamination from raw to finished products. To accomplish this, all facilities in the fish market must allow for a separation of its equipment, working areas, and storage areas when handling fresh and processed fish products.

Floors

Concrete floors should be used in market areas - a minimum floor slope of 2.5 cm (1 in) per 2.4 m (8 ft) is required. Outside concrete pads (sloped to a drain) are required for all receiving, shipping and storage areas.

Drains

Drains should be of a trough design. The trough drain should be a minimum of 15 cm (6 in) in width and depth, with a minimum slope of 2.5 cm (1 in) per 1.8 m (6 ft). The distance from the drain to any wall should not exceed 4.57 m (15 ft).

The concrete lip of the drain should be equipped with an L-shaped angle iron embedded and anchored into the concrete to protect the concrete when the gratings are being removed during plant clean up.

Circular drains may be acceptable, providing the grates are large enough to prevent clogging and there is at least one drain for each 37 sq m (400 sq ft) of floor area.

Drains must be equipped with traps or other devices to preclude the entry of gases or vermin into the building through the drain.

Waste water should be discharged into a community sewerage system or to an approved on site disposal system.

Walls

Wall surfaces (floor to ceiling) in selling areas must be durable and impervious to water.

Sealed concrete block walls are acceptable.

Good one-side plywood (1.2 cm [½ in] minimum) is acceptable for outside and interior walls provided the studs are located on a 15 cm (6 in) concrete curb (i.e. one layer of concrete blocks) to prevent rotting at the floor-wall joint. The bottom edge of the plywood should overlap the concrete curb and be liberally caulked to seal out moisture.

Barker board or similar plastic panels (1.2 cm [½ in] minimum) are acceptable. Standard arborite, particle board or dry wall is not acceptable.

Wall Coating

Plywood and concrete surfaces must be sealed and then coated with a durable enamel or epoxy finish.

Walls must be light coloured and smooth so that dirt can easily be seen and easily removed.

Ceilings

Ceiling surfaces must be smooth, impervious and washable with no exposed pipes, joints, or open support beams.

Drywall is not acceptable, as it will not tolerate damp conditions.

Lighting

Safety shields should be installed on all light fixtures throughout the market area to prevent shattered glass from falling into food products.

A minimum lighting intensity of 50-foot candles is required on all working surfaces in the market areas. A minimum lighting intensity of 30-foot candles is required in all areas of a market.

Display *equipment*

Display equipment must be constructed of approved materials such as stainless steel, aluminum or plastic.

Water Supply

Water and ice must be of potable quality from an approved source (i.e. disinfected/treated municipal water supply).

The water supply must be tested for compliance with drinking water standards before a license can be issued.

An approved water treatment system may be required for a water supply, which utilizes a surface source or a shallow well.

An adequate supply of potable water is required. Sufficient hot water at a minimum of 43°C (110°F) must also be available for cleaning purposes.

Refrigeration

Freezer and cold storage requirements will vary from one application to another. It is important that adequate refrigeration and freezer space is provided. For most operations, a *walk-in cooler* will be required. The freezing equipment must be able to maintain a minimum temperature of –18°C (0°F) and, where freezing of fresh fish occurs, blast-freezing capabilities must be provided. The interior of refrigerator units must be constructed and equipped so that all surfaces are smooth, durable, non-absorbent and easily cleanable. The floor of a walk-in cooler must be sloped

(minimum 2.5 cm [1 in] every 2.4 m [8 ft]) to a drain. Floor insulation for walk-in coolers is highly recommended.

Toilet Facilities

Toilet facilities must be provided.

. Toilet rooms must not have direct access from the market selling/display area. An anteroom or a 90-degree turn into the toilet room is satisfactory. Toilet rooms shall be equipped with self-closing doors.

. A floor drain should be provided in each toilet room.

A floor drain should be provided in each toilet room.

Toilet rooms must be finished with durable and impervious materials and equipped with soap and towel dispensers.

Offal Disposal

A concrete pad sloped to a drain, and large enough to accommodate offal containers should be provided outside the plant. Offal containers must be water tight, constructed of approved materials and equipped with fitted covers.

FISH SPOILAGE

8.1 Define fish spoilage

Undesirable postharvest changes that take place when the fish is caught and dies leading to postmortem changes in colour, texture, taste, produce smell, go soft becoming completely spoiled and useless. These changes are used to determine quality and price of the fish. Causes of fish spoilage

The two main real causes of fish spoilage and these are:

(i) Bacteria (germs): different types categorized into-

- Spoilage and
- Poisonous

(ii) Enzymes (acids): properties of enzymes (biological catalysts, inactive by high temp being proteins, works best at neutral Ph, specifics for one substrate molecule)

8.3 Quality assessment methods

Use of sensory or organoleptic quality assessment methods: Appearance (sight), Texture (touch), Smell, Taste, Gills, Eyes, Scales.

Other causes of fish spoilage:

(iii) High Temperatures

(iv) Rough or bad handling: throwing, dropping, standing/stepping on fish

(v) Pro-longed period or delays in handling fish

(vi) Delays in selling fish

(vii) No or lack of ice

Importance of fish freshness

The following characteristics are associated with importance of fish freshness:

(i) No health effect to the consumers and they are happy for buying good quality fish

(ii) Long shelf-life due to clean environment

(iii) Get better or good price

(iv) Quick turn-over due to many customers

(v) Fish has access to local, regional and international markets

8.5 Places where bacteria and enzymes are found

- **Bacteria:**

(i) In the air, everywhere

(ii) Dirty hands

(iii) Dirty water around landing sites

(iv) Dirty equipment & utensils

(v) Rubbish bins and poor/dirty environment

(vi) Dirty Ice

(vii) Dirty clothes, e.g. protective gear

(viii) Open defecation

(ix) Unclean Toilet

(x) Dirty Salt

(xi) Insects

(xii) Animals

- **Enzymes:**

(i) Guts in the stomach

(ii) Fresh of fish

8.5.1 Conditions favourable for bacteria growth

(i) Water

(ii) Food

(iii) Nice warm temperature

8.5.2 Conditions favourable for Enzymes**:**

No effect they continue to operate as normal but now affect the fish itself by digesting it.

*8.*5.3 Conditions not favourable for bacteria growth

(i) Cold temperatures (Ice, Chilling & Freezing)

(ii) Dry conditions (Sun-drying, Salting)

(iii) Very hot temperatures (Smoking, Cooking, Frying, Canning)

8.5.4 Prevention of fish spoilage (Control measures)

(i) Use of Ice

(ii) Use refrigeration facilities

(iii) Use of Freezing facilities

(iv) Sun-drying

(v) Salting

(vi) Smoking

(vii) Boiling/cooking

(viii) Frying & Canning

FISH PRESERVATION AND PROCESSING METHODS

(i) Chilling: is the process of cooling or lowering the fish to a temperature approaching that of melting ice or slightly above minus one degrees (-1^0c) or holding the fish just above freezing point. It is a short term preservation method.

(ii) Freezing: in broad terms, can be defined as" the process of lowering the temperature of fish until most of the liquid is changed to solid (ice crystals)".

(iii) Salting

Salting is the addition /application of salt to fish so as to preserve the fish or prolong its shelflife. Below are salting methods:

(a) Brine solution

This is wet salting method in which the fish are immersed in a solution of salt in water.

(b) Dry salting

This is a dry salting method in which granular salt grains are rubbed into the surface of the fish and then dried.

(c)Kenching

This is a dry salting method in which granular salt is rubbed into the surface of split fish. The fish are stacked with a sprinkling of salt between each layer of fish. The liquid (pickle) which forms is allowed to drain away. A heavy object is placed on top to press on the fish to assist removal of water from the fish.

(d) Pickle salting

This is a wet salting method in which fish are covered with salt and packed in water-tight containers in layers with salt sprinkled between each layer. The pickle which forms covers the fish. In case the fish is not covered completely in 3-4 hours, saturated brine is normally added to completely immerse the fish. A heavy cover should be placed on top of the fish to hold them down or below the surface of the pickle.

Preparation of salted fish (De-Salting)

This is the removal of salt from the fish product

Methods or procedures of de-salting:

(i) Soaking in cold water overnight then rinse/wash with clean water to remove access salt. No need to add salt during cooking process

(ii) Soaking in lukewarm water for 30minutes then rinse/wash with clean water to remove access salt.

(iv) Sun-drying

This is the use of solar energy (Sun) to preserve fish by reducing the amount of water in fish. Drying has evolved as a traditional method of preserving fish, through the action of the sun and wind is used to effect evaporative drying. This method is the most widely used in the country.

(v) Smoking:

(i) *Cold smoked*: This is process when during the smoking process, the temperature at no time rises to a level where the flesh is cooked (i.e., the protein is denatured). In practice, this means a maximum temperature of approximately 30 - 40°C and is only really possible in temperate climates. The product has to be kept under refrigeration to prolong its shelf life.

(ii) *Hot smoking*: This is where the temperatures are higher than 60^{o}C and the product is cooked. The product can be stored in the ambient temperatures in a less humid environment. Traditional smoking in tropical countries falls within this category.

10. FISH PACKAGING & TRANSPORTATION

Fish packaging and labelling are very important stages in the fish value chain. For instance, the package should protect the product from contamination and prevent it from spoilage, and at the same time it should:

(i) Extend shelf life of a product

(ii) Facilitate distribution and display

(iii) Give the product greater consumer appeal (Value addition)

(iv) Facilitate the display of information on the product (Labelling)

Modes of transport:

The following are the common modes of transport used by fish farmers to take the produce to the markets:

(i)Trucks/Lorries

(ii)Buses

(iii)Vans

(iv) Bicycles

(v) Foot

(vi) Refrigerated vehicles

11. APPROPRIATE STORAGE FACILITIES

Outlined below are considered appropriate storage facilities for keeping fish:

(i) Cool boxes

(ii) Wooden boxes

(iii) Metal boxes

(iv) Fibre boxes

(v) Cold Stores/ rooms

(vi) Sacks

(vii) Baskets Fridges,

12. HAZARD ANALYSIS CRITICAL CONTROL (HACCP) CONCEPT

12.1 Definition

Hazard analysis and critical control points, or **HACCP** is a systematic preventive approach to *food safety* and pharmaceutical safety that identifies *physical, chemical,* and *biological hazards* in production processes that can cause the finished product to be unsafe, and designs measurements to reduce these risks to a safe level. **The HACCP plan is designed to control all reasonably likely food-safety hazards.**

12.2 Importance

The purposes of HACCP, hazards only refer to the conditions or contaminants in food that can cause illness or injury to people.

12.3 Identification of Hazards

The procedure to determine whether the hazard can occur at any step in the production process, and if so, whether control measures exist. If the hazard can be controlled adequately, and is not best controlled at another step, and is essential for food safety, then this step is a CCP for the specified hazard. A decision tree can be used to determine CCPs.

12.4 Types of Hazards

Hazard*: a biological, chemical or physical agent that is reasonably likely to cause illness or injury in the absence of its control.*

- **Physical Hazard:**

Any potentially harmful extraneous matter not normally found in food e.g. metal, glass

- **Biological Hazard:**

Foods can contain biological hazards. These hazards can come from raw materials or from food-processing steps used to make the final product, e.g. Bacteria, Viruses, Parasites (protozoa). The major sources are: (i) Food infection and food intoxication and (ii) Spore forming and non-spore forming bacteria.

- **Chemical Hazard:**

Chemical contamination can happen at any stage in food production and processing, e.g. Mycotoxins (e.g. aflatoxin), Scombrotoxin, Ciguatoxin, Shellfish toxins.

12.5 Application (Steps)

Task 1 - Establish a HACCP team

Task 2 - Describe the product

Task 3 - Identify the product's intended use

Task 4 - Draw up the commodity flow diagram

Task 5 - On site confirmation of flow diagram

Task 6 - Identify and analyse hazard(s) - (Principle 1)

Task 7 - Determine the critical control points (ccps) - (Principle 2).

Task 8 - Establish critical limits for each ccp - (Principle 3)

Task 9 - Establish a monitoring procedure - (Principle 4)

Task 10 - Establish corrective action - (Principle 5)

Task 11 - Verify the HACCP plan - (Principle 6)

2. 0 MARKETING CHANNELS

Definition of Marketing

Marketing practice tended to be seen as a creative industry in the past, which included advertising, distribution and selling. The trainees will be able to understand the existing marketing channels. Fish marketing involves the flow of market information from the producer to the consumer through a channel consisting of producers, wholesalers, processors and retailers.

Distribution channel:

Participants in the industrial marketing system are linked by both direct or formal and indirect or informal channels.

- ✓ **Formal channel (**Direct) are ones in which the producer has control over the distribution of his products pond to consumer e.g. fish from the own aquaculture facility to the own retail shops. In Zambia for example, lake harvest take their fish from cages directly to retail outlets.

- ✓ **Informal channels** (Indirect) are identified by independent middlemen who limit the control of the producer that they can exercise over the distribution of their product

IDENTIFICATION AND DEVELOPMENT OF A MARKETING CHANNEL

A marketing channel is path involving various players or actors that facilitate the transfer of ownership of goods/services from the point of production to the point of consumption. An alternative term is distribution channel or 'route-to-market'. It is a 'path' or 'pipeline' through which goods and services flow in one direction (from vendor to the consumer), and the payments generated by them flow in the opposite direction (from consumer to the vendor). A marketing channel can be as short as being direct from the vendor to the consumer or may include several inter-connected (usually independent but mutually dependent) intermediaries such as wholesalers, distributors and retailers. Each intermediary receives the item at one pricing point and moves it to the next higher pricing point until it reaches the final buyer.

Importance of a marketing channel

- Links producers to buyers.
- Performs sales, advertising and promotion.
- Influences the firm's pricing strategy.

WHOLESALER

Wholesale operations involve selling to retailers, other wholesalers and industrial or institutional users. A wholesaler may buy directly from the producer (fish farmer) and sell to other wholesalers or retailers. Wholesalers take title to the products they handle and are responsible for geographic distribution of the product. The biggest problem in wholesaling involves lack of assurance of steady supply of product to keep operating throughout the year.

RETAILERS

Retailing is the selling of a product directly to the final consumer. This involves the use of retail outlets such as kiosks, stalls in urban markets or periodic rural markets. The success of retail outlets lies in their location relative to availability of customers in the area.

CUSTOMER

Customers are the people or other businesses that want products or services available in the market and are willing to pay for them.

3. 0 AVAILABLE MARKETS

- ✓ Location, Distance, Accessibility (buyers available)

4. 0 MARKET TRENDS AND REQUIREMENTS

- ✓ Consumer preferences (quality, sizes, species, taste)

5. 0 STRATEGIC PLAN FOR PRICE DETERMINATION

- ✓ Packaging (value addition)
- ✓ Labeling (value addition)
- ✓ Size
- ✓ Strategies to obtain better price margins (e.g. strategic stocking, joint selling, futures contracts with buyers)
- ✓

Strategy to obtain better price margins

1.0 GROUP MARKETING

Group marketing is when individuals or groups of people gather their produce together and market collectively. Fish farmers in this case can improve the quality of their produce by stocking the same type of fish and package them professionally.

Advantages of group marketing

- Improves economies of scale

  Improving economies of scale implies a **division of labour** to make the whole operation more efficient. If a group of farmers decide to adopt this strategy, a small group of trusted individuals belonging to the group need to take the responsibility for selling the goods, keeping accurate records, dividing the proceeds among the individual members of the group and organizing production and development.

- **Lowers transaction costs**

  Bulking up small parcels of produce into truck-loads of goods enables the sellers to share the costs of marketing goods outside their immediate location at a competitive market price in the event that the local market is offering a lower price for the produce.

- **Exclusion of middle men**

  If there are fewer traders, acting as intermediaries between the farmer and the consumer, the farmer and the consumer will benefit because it will lower transaction costs.

- **Incentive to increase production**

  Collective marketing should make marketing easier. This should have the effect of increasing the farmers' incentive to produce larger surpluses which will make their fish farms more productive.

- **Improves access to credit**

  Collective activity might also help farmers to obtain credit. They may be able to borrow money to buy inputs and improve their farm which, in turn, can increase their income.

  If farmers could borrow from an established bank the rate of interest may not be so high and the farmer's bargaining relationship with the trader will be strengthened.

- **Obtaining communal equipment and services**

  It is much cheaper and easier for government and development agencies to organize training and agricultural extension services for groups of farmers rather than for individual farmers. Even if all farmers find it difficult to attend training sessions, individuals from the group can pass on advice and training to their fellow group members.

Groups of farmers can also construct communally owned storage facilities. If farmers can store their products they can improve their marketing performance. Many small roads and farm tracks cannot be used by large trucks but communal storage facilities can be erected at access points on roads making it possible for farmers to collect products from group members into lorry-load quantities. Sorting, grading, weighing and packing facilities can also be established at these sites.

- **Social advantage**

  Some farmers have misconceptions about any form of collective activity. They are suspicious of hierarchical systems and may think that collaborative activity of this kind will be run by a small clique of people over whom they have no control and with whom they may have conflicting interests. Many efforts made to bring farmers together in the past have become corrupt or become controlled by self-seeking or inefficient managers. It is important, therefore from the outset, to establish a proper **constitution** governing the activities of the group based on democratic lines. Any constitution should make sure that the group has no control over the assets of individual farmers nor should any farmer be prevented from leaving the group if they wish.

Disadvantages of group marketing

There may be many reasons why collective marketing schemes would be unsuitable for some farmers, including the following:

- Mutual distrust among members. Some farmers may not trust their neighbors sufficiently and may not wish to join with them in any kind of collective activity. In areas where there is hostility between farmers no amount of coxing will get them to co-operate with each other.

- Lack of co-operation among members. Some farmers may feel that they already make a good living from their work and may produce a product that is widely sought-after. Others may find that they can obtain satisfactory sales prices at roadside or village markets.
- Lack of skills. Still others may not have the necessary skill, knowledge or leadership to understand how to work with each other.

- Dishonesty and non-transparency especially on the marketing team may lead to conflicts.
- Thefts and losses can occur in poorly secured central facilities.
- May require heavy capital investments if the group has to put up its own central storage facilities and acquire vehicles for transport.
- Losses may occur due to poor record keeping.

PART 8: BUSINESS MANAGEMENT IN AQUACULTURE

Description of the manual

Skills in business management in aquaculture is important to enable students have practical knowledge to pursue as a business venture. Some of the factors that should be considered are business planning, business strategies in aquaculture, market prices and record keeping.

Organization

The manual section is a reading and hands-on practical guide on skills in business management in aquaculture.

		How to calculate	YEAR 1 [2017]	YEAR 2 [2018]
A	Quantity of products (3,920kg annually of fish)		3,920kg	3,920kg
B	Price per unit of the product (reached or expected to be reached when product will be sold)		20	23
C	VALUE OF PRODUCTS	[C = A x B]	78,400	90,160
D	Variable costs		7,290	7,300
E	Fixed costs		9,000	2,000
F	TOTAL EXPENSES	[F = D + E]	16,290	9,300
G	PROFIT BEFORE INTEREST/TAXES	[G = C – F]	(62,110)	(80,860)
H	Interest, Taxes		2,500	4,000
J	NET PROFIT	[J = G – H]	(59,810)	(76,860)

INTRODUCTION

BUSINESS MANAGEMENT IN AQUACULTURE

Aquaculture business is the farming, management, production, and marketing of aquaculture products such as fish and other aquatic organisms. The Aquaculture business field includes resource management, rearing of fish and sales. It involves management of a profitable aquaculture enterprise. Emphasis is on business planning, record keeping, production planning, farm labor management and fish farm management.

Business management practices involve doing the following:

- Keeping records of income and expenditure
- Buying and selling on credit
- Calculating your profit or loss
- Setting a good price and good planning

Good business management can be represented by four P's: Product, Place, Price and Promotion. This can further be explained by giving an example of a chair with four legs.

Each leg of the chair represents a P. If one leg is broken, you will no longer be able to sit on the chair. The four P's always go together. If no attention is paid to one of the four P's, the business will fall apart.

To make your business successful you have to consider the following questions:

1. **Product**
    - What is your product? Is it what the people in your village need and will buy?
    - Is somebody else already selling a similar product?
    - Will people still be interested in your product? What makes your product different from others?
    - What is the quality that the people expect from your product?

2**. Place**

- Will there be many people at the place you want to sell your product?
- Where will you buy everything you need?

3. **Price**

- How much does it cost to produce your product?
- For what price are other people selling the same product?
- What price do you have to set to make a profit?

4. **Promotion**

- Do you have a friendly approach to your customers?
- Is your product of good quality?
- Do you always have your products available and do you finish your orders in time?
- How can you make the place where you sell your product look clean and attractive?
- Is it possible to advertise your business in the papers or on the radio?

What is an enterprise

An enterprise can be defined as a **venture** that is aimed at making a profit. The ultimate objective of an enterprise is to create wealth, make money, provide a livelihood for the owners, and create employment while providing the target customers with goods and services to their satisfaction.

The art of creating enterprises can be defined as entrepreneurship. There are various definitions of the term 'entrepreneurship'. The most commonly used definition of entrepreneurship is '**the art of creating or developing a business through innovation, creativity, progressive imagination and risk taking initiative'.**

Forms of business

There are five (5) forms of businesses an entrepreneur can opt for in Zambia. Below is a table showing the forms of business, registered under which Act and registered by whom.

Table 1.1: Forms of business

	Forms of Business	Types of Companies	Registered under	Registered by
1	Sole Proprietorship	Sole Trader	PACRA Business Names Act No. 389	Registrar of Companies
2	Partnership	Private Partnership	PACRA Companies Act (Cap 388)	Registrar of Companies
		Public Partnership		
3	Limited Company	Private Company Ltd (Pvt)		
		Public Company Ltd (PLC)		
4	Co-operative Society	Limited Liability (share capital of the members)	Co-operative Societies Act No.20 of 1998	Registrar of Co-operative Societies
5	Associations[1]	Societies	Societies Act (Cap119)	Registrar of Societies

PACRA – Patents and Companies Registration Agency

Pvt - Private Company Limited

PLC - Public Limited Company

It is very important that an entrepreneur looks at these forms of business critically before settling on any of them. These forms of business have their advantages and disadvantages. The reason for doing so is to see which one of them will provide the best option given the available resources and business objectives.

Below is a simple criterion for comparing the five different forms of businesses:-

- Will the form of business help the enterprise to easily access capital?

[1] Depending on the nature of agreement, associations may do business and make profit. In most cases, they operate as non-profit making organizations. When they do business they need to register with ZRA to get the necessary tax clearance and other requirements.

- Will the form of business have continuity?
- Is the liability of the owner limited?
- Does the form of business promote good governance?
- How does management participate?
- Is it easy to transfer ownership?
- What are the record keeping requirements?
- How do the tax burdens compare?
- What is the cost of starting and registering the business?
- How simple is it to start the business?

What is a Sole Proprietorship?

This is a business owned by one person. The owner has all the authority to make decisions about the business. The procedures of starting the business are simple and the cost is low.

Advantages

- All the business profit belong to the owner
- The cost of starting the business is low
- Easy to start the business and get it registered
- The owner makes decisions

Disadvantages

- The owner is personally liable for all losses and debts
- It is difficult to borrow many from the banks
- There is no continuity
- The owner suffers alone; if the business is bankrupt, personal funds can be used to pay off the debtors.

What is Partnership?

Partnership is a form of business formed by two people, with a maximum of twenty partners. To start a partnership, partners must enter into a Partnership Agreement that can either be

verbal or written. Entrepreneurs planning to start a partnership are strongly advised to put the partnership agreement in writing to avoid unnecessary future disputes.

A Partnership Agreement may include the following:-

1) Line of business
2) Capital contributions
3) Duties of partners
4) Profit sharing ratio and
5) How to resolve conflicts

Advantages

- Earnings flow directly to partners
- Can bring together people with different skills, experiences and knowledge
- The cost of starting the business is low
- It may be easier to raise capital
- The prospects of shared risks
- In the event of sickness of one partner, the other partners can fill in the gap

Disadvantages

- Just like sole proprietorship, a partnership has unlimited liability
- Conflict of interest amongst partners
- Mistrust among partners
- Delayed decision making
- Shared profits
- Laissez-fair attitude

There are a number of different limited companies. Below is a brief description of each one of them according to the Companies Act.

What is a Private Limited Company?

A Private Limited Company is one with share capital. It may not have more than 50 shareholders and it is prohibited from making invitations to the public to purchase its shares or debentures. If it is wound up and its assets are insufficient to cover its liabilities, the liability of its members/shareholders is limited to the amount left unpaid on their shares (section 122,265 and 266). This is the most common type of Company obtainable in Zambia.

What is a co-operative?

A co-operative is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise not prohibited by law.

A co-operative usually has a democratic form of governance where the members own and control it. There is equitable distribution of earnings just as there is equal number of shares per member. Co-operatives are formed for economic gain, marketing and other strategic reasons such as cost sharing.

In a co-operative, all the members have one vote each in the decision making process. Usually a Board of Directors runs the affairs of the co-operative.

Advantages of a Co-operative

- Favorable taxation
- Limited liability to the extent of members' contributions
- The cost of registration is low
- Shared losses and risks
- Government is trying to reduce huddles on registration
- District Co-operative officers are available in every district to help members

Disadvantages of a Co-operative

- Co-operatives are said to have a poor performance
- Political interferences and internal politics
- Decision making is rather slow
- Procedure for its formation and registration is rather slow and involving

What is an Association?

Associations vary according to the functions that they undertake. There are those who deal in advocacy for various human endeavors like human rights, children's welfare, etc. Others are business associations.

Like Co-operatives, Associations can be defined as a group of individuals who voluntarily enter into an agreement to accomplish a purpose. Examples of some Associations are:-

- District Business Associations
- Trade Associations
- Alumni Associations
- Professional Associations
- Sports Associations etc.

Advantages of Business Associations

- They serve as very good resource centres for business enterprises.
- They establish very good and effective networks for the creation of enabling business environment.
- Cost sharing which leads to cost savings.
- Ability to lobby government for a favourable business environment.
- Ability to lobby the donor community for assistance.
- Provide access to training through shared initiatives.

Disadvantages

- Organising associations can be complicated.
- Political interferences and internal politics.
- Decision making can rather be slow.
- Procedure for its formation and registration is rather slow and involving
- Poor governance trend in some cases.

Record keeping in Aquaculture

Most businesses have stopped because of failure to keep information about the aquaculture enterprises. This is because any failures or successes of the business can only be noticed if correct data is kept. Such data help in the following

1. Assessment in the variation of the unit cost of production
2. Establishment of efficiency in the management of the farms
3. Description of the most efficient practices and techniques of the farm operation
4. Realistically study the operations of the farm
5. Compare the efficiency of the farm against other farms or enterprises at the farm

The types of data in aquaculture include:

1. **Assets and liabilities**

a) Assets are properties that are owned or owed to the aquaculture business; They can be:

- ✓ Current – those which may be sold readily for cash – fish seed
- ✓ Intermediate – those that may be sold for cash in time period of more than one year but not later than 10 years e.g breeding stock, aerators, tractors etc.
- ✓ Long term (Fixed assets) - those that can be sold for a long period of time and if sold they can change the nature of the business.

b) Liabilities are obligations or debts owed to someone else. They are also categorised into three:

- ✓ Current liabilities - financial obligations which become due with one year e.g rent, taxes
- ✓ Intermediate liabilities – financial obligation due over one year but not later than 10 years.
- ✓ Long term liabilities – debts which occur for the purchase of long term assets e.g land contracts and repayments is from 10 to 40 years.

2. Costs

These constitute the main inputs in the fish seed production. Two types

- ✓ Variable costs (production and labour): costs that change with production. Examples include

- Fry costs
- Breed stock cost
- Feed cost
- Fertilizer cost
- Electricity/fuel
- Packaging plastics/containers
- Transportation costs
- Maintenance costs of machinery and tools
- Variable labour costs
  - Man hours/day
  - Wages in cash and kind

✓ Fixed costs: Costs that do not vary with the level of production. Examples include

- Salaries and wages to administrative personnel
- Salary of the owner
- Telephone, postage and office accessories
- Travelling expenses
- Legal/auditing/technical assistance
- Insurance

Note: Total cost (TC) = fixed cost + variable cost

3. Production data

✓ Stocking data
✓ Growth data
✓ Water quality data
✓ Harvesting data
✓ Feeding data
✓ Fish disease data etc

Every farm manager ensures that data is kept in the appropriate form.

Business planning tools

These are tools and methods that are used to help in formulating profitable farming systems. These include;

(i) Budgeting

- Complete
- Partial
- Break-even

(ii) Gross Margin analysis

Budget analysis

A budget is simply a plan to coordinate resource flows in and out of the business to achieve a given set of objectives.

Steps in estimating Complete Budget

1. Estimate what can be produced and the limitations on what can be produced
2. Determine the area or number of fish/fingerlings
3. Estimate the yield
4. Estimate the prices of fish/fingerlings
5. Estimate the cost of labour and any machinery and equipment that may be used on the farm
6. Estimate other fixed costs such as depreciation and repairs
7. Calculate Total Cost and Total Returns and the difference between the two is called **Net Farm Income**

Gross income (GI) – TVC = Gross margin

Gross Margin – Fixed Costs = Net Farm Income

Gross Income – (TVC+FC) = Net Farm Income

GI – TC = Net Farm Income

Gross income/revenue includes;

- Cash and credit sales
- Value of amount consumed on the farm
- Value of the amount given away
- Value of amount used for in-kind payment

At a farm there may be several subdivisions such as poultry, table size production and fish seed production each subdivision is called an enterprise.

Example of enterprise budget

Item		Amount
Production (Kg)		2, 000
Price/kg		0.35
Gross Revenue	(ZK)	700, 000
Variable costs (ZK)		
Broodstock		2, 000
Feed		90, 000
Hormone		32, 000
Chemicals		10, 000
Labour		75, 000
Electricity		2, 000
Fuel		1, 000
Total Variable Costs		212, 000

Gross Margin (ZK) **488 000 (Gross revenue – TVC)**

Break even analysis

Breakeven analysis allows the manger to determine the production or income at which all costs are covered.

Breakeven cost = cost per unit production/yield per unit of production

For example, the fingerling production at NARDC shows the variable cost is K25, 000 in 1000m^2 ponds. The total fixed cost is K2, 000. The yield is 200, 000 fingerings at K0.35 each fingerling.

TC = 25, 000 + 2, 000 = 27, 000

Yield = 200, 000 fingerlings

BEP = 27, 000/200, 000 = K0.14/fingerling. This means that the fingerling produced should not be sold for less than K0.14. The price of K0.35 allows the farm to make profit of K0.225/piece.

Breakeven price to cover variable expense

= Variable expense/yield

=25, 000/200,000 = K0.13

BUSINESS PLAN

Is a worked out description of how they are to be set up and developed, the timescale for the development, and what would be the expected costs and returns. It's a document that: Demonstrates that the viability of your aquaculture business profitability and tests your ideas into reality.

IMPORTANCE OF BUSINESS PLAN

Your business plan is a framework which your business must operate within. It will ultimately determine whether your business succeeds or fails.

Preparation of a comprehensive plan will not guarantee success in raising funds or mobilizing support, but having no plan at all will likely result in failure.

It saves you the trouble of pursuing a futile venture because it is designed to help you analyze whether the business is practical or not.

Business planning Serves as a tool of communication. Banks and investors will look to your plan for evidence that your company can succeed. Your partners and employees will look at it as a blueprint for the future, bringing together diverse elements such as marketing, sales and operations into one document. A business plan helps you foresee potential risks and develop strategies for dealing with them before they occur.

It also helps you to clarify what the objectives of the business are and to identify the strategies needed to achieve those objectives.

A business plan helps you decide whether it is financially worthwhile to start an enterprise based on your ideas. It helps one ensure that one has thought through all the crucial aspects of the business idea and helps you organize your ideas and to decide on how best you can get started.

COMPONENTS OF A BUSINESS PLAN

The Executive Summary

The purpose of the executive summary is to capture the interest of the investors/lenders so they will want to find out more about the venture. Therefore, this section is first, and in some ways is most important. This section should emphasize key issues. The following information should be addressed in the executive summary:

- **Company profile**; a company profile includes a brief history of the company and the goods and services it provides.
- **Nature of the product/service being offered**
- **Size and growth trend of the market**
- **Make-up and background of the management team**
- **Financing requirements**
- **Key projections (sales, gross profits, net income)**
- **Proposed use of funds**

The executive summary is written last, after the rest of the plan is completed.

Business Description

This section of the business plan should provide the reader with a more detailed overview of the company and the nature of the product/service offering. It should include the following:

- **Mission Statement**; is a short written statement that guides the actions of the organization , spells out its overall goals, provides a sense of direction and guides decision making.

- **History behind the idea or current business**
- **Company's current or proposed legal form**
- **Proposed entry strategy and time line of events**

- **Description of the initial product/service** (including any anticipated competitive advantage)

- **Product research and development**; this aims to come up with goods and services that meet the needs of tomorrow's customers.

Market Analysis

The main objective of this section is to convince the reader that an explosive market opportunity exists, and that the entrepreneur understands it well enough to capture a share large enough to support the new venture. The entrepreneur can do this by addressing the following areas:

- Description of the industry
- Targeted markets
- Marketing research
- Competition
- Barriers to entry

The Management Team

The strength of the management team plays a key role in investors' and lenders' decision to fund a venture. The objective of this section is to convince the potential investor that the entrepreneur has a management team that can effectively manage the product/service into the market place and make the venture a success. The key areas to cover are:

- Background and primary responsibilities of the management team
- Organizational structure
- Board of directors/advisors
- Ownership

Operations

This section should provide an overview of the strategy for implementing the business plan. The objective here is for the entrepreneur to demonstrate that he/she has an understanding of how the plan will be implemented. Also, this section will help the entrepreneur focus on relevant costs associated with implementing the plan. The entrepreneur must remember to incorporate the assumptions made in this section into the assumptions in the financial section of the business plan. Depending on the type of business, the entrepreneur should address the following key areas:

- **Marketing Strategy**; is a process that can allow an organization to concentrate its limited resources on the greatest opportunities to increase sales.
- **Production Plan**

- **Personnel;** that is the people you will employ
- **Customer Support**
- **Future research and development** plans

Farm management

Farm management involves planning and operation. If planning is overlooked the aquaculture enterprise production is likely to fail. The first farming decision should therefore be planning, unfortunately mostly is economic in nature.

Management is the ability to organize resources in the most efficient and profitable manner. The function of management is at two levels:

1. Organizational – decisions which usually concern planning for long periods.
2. Operational – decisions regarding physical implementation of the plans

The farm manager makes decisions on the following:

1. What species of fish to produce
2. How much of the selected species to produce
3. What size and quantity to produce
4. What mix of resources and technology to use
5. When and where to sell or buy
6. How to finance the operation

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