TVET CERTIFICATE V in ANIMAL HEALTH

FISH FARMING

ANHFF501

PERFORM FISH FARMING

Competence

Credits: 10

Learning hours: 100

Sector: Agriculture and Food processing

Sub-sector: Animal Health

Module Note Issue date: NOVEMBER, 2020

Purpose statement

This core module provides the skills, knowledge and attitude for a learner to be competent in a range of routine tasks and activities that require the application of practical skills in a defined context of the fish farming.

Upon completion of this module, the trainee will be able to:

- Select fish species
- Construct a fish farming enclosures
- Stock farming enclosures
- Manage fish production
- Control fish diseases and predators

Table of Contents

4.Learning unit 4: Manage fish production	4.1. Proper description of fish farming systems in terms of input levels.	32
	4.2.Monitoring of dissolved oxygen, water level, pH and turbidity	
	4.3.Adequate maintenance of water supply channels, inlet and outlet	
	4.4. Proper fish feeding according to the stocking density, type of production and water quality.	
	4.5.Appropriate integration of fish farming with livestock and crops	
	4.6.Proper rearing of fish in cages, pens, tanks and Hapas	
	4.7.Adequate fish harvesting according to the types of fish pond, fish breed and market requirements	
	4.8.Adequate fish post-harvesting according to the types of fish breed and market requirements	
	4.9.Adequate record keeping and interpretation of fish rearing	
5.Learning unit 5: Control fish diseases and predators	5.1.Proper identification of predators and specific diseases of fish	64
	5.2.Accurate respect of hygiene and biosecurity measures	
	5.3.Appropriate establishment of prophylactic plan	
	5.4.Proper selection of bio-chemical prevention products	
	5.5. Proper administration of bio-chemical prevention product	
	5.6.Adequate record keeping and interpretation of zoo-sanitary data	

List of figures

List of tables

Total Number of Pages: 77

Introduction

Fish farming or pisciculture is the principal form of aquaculture, while other methods may fall under mariculture. Aquaculture is one of the emerging enterprises selected by farmers for development and promotion. The growing supply gap in fish production from the capture fishery for domestic and regional demand could easily be met by increased expansion and production in the enterprise. Fish farming is a key source of protein and other essential nutrients, and provides an important link with household nutrition and improved household incomes. Fish farming is therefore suitable for areas with small and holdings and optimizing use of water for production.

Learning Unit 1 – Select fish species

LO 1.1 – identify fish species

- Content/Topic 1: Physical appearance of Common fish species in the region

A. Oreochromis niloticus (Isamake)

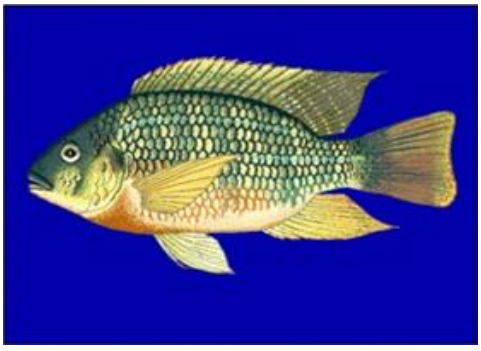


Figure 1: Oreochromis niloticus

B. Cyprinus carpio (Common carp: Inkuyu)

Figure 2: Cyprinus carpio

C. Clarias gariepinus (African catfish: Inshonzi)

Figure 3: Clarias gariepinus

D.Limnothrissa miodon (Isambaza)

Figure 4: Limnothrissa miodon

E.Protopterus aethiopicus (Marbled lungfish or Mamba)

Figure 5: Protopterus aetiepicus

F.Haplochromis sp(indugu)

Figure 6: Haplochromis sp

G.Lamprichytys tanganicanus (Rwanda rushya)

Figure 7: Lamprichytys tanganicanus

LO 1.2 – Describe fish species

- Content/Topic 1: Characteristics of fish species

A.Characteristic of *Oreochromis niloticus*

 	Description: Fish of 30 cm in average, high-backed. Its skin is covered with scales + / -large. Its color is usually gray-silver; the morphology of males is different from that of females. Potential productivity: Fish weights 3 kg in adulthood. Annual productivity of 100 kg per ha (extensive) to 50 kg per 100m ² (intensive/ fish farming). It can be reared in combination with carp or catfish (up to 75 kg per 100m² in intensive fish farming). Hardiness and Environment: Freshwater fish, especially of lakes or ponds of the tropical belt of the globe. Requires water Temperatures between 14°C and 33°C. It can be reared in fish farming and tolerates water With low oxygen, even if it is unable to absorb oxygen directly from air. It tolerates changes in water line (Rice farming). Fish very resistant, with fast growing and easy reproduction, wide range in fish feeds.

B.Characteristic of Cyprinus carpio

	Description: Elongated fish of an average of70 cm, covered with scales of medium size. Its **color** is usually brown on the back, golden on the side and pale yellow on the abdomen. The mouth is equipped with 2 pairs of barblles (sensitive filaments).

	**Potential productivity**: fish of from 4 to 10 kg in adulthood. Annual productivity of 100 kg per ha (extensive) to 50 kg per 100 m² (intensive/fish farming). It grows in Combination with Tilapia (up to 70 kg per 100m² in intensive fish farming). Hardiness and environment: Introduced in Rwanda, it easily reproduces. This fresh water fish can be reared in fish farming but requires minimum water line of 50cm (not suitable for rice farming).Tolerant to various temperatures (3-35°C).

C.Characteristic of *Clarias gariepinus*

	Description: Fish of long body of average 90 cm in length, cylindrical body in its interior parts. Its skin has no scale and there is an adipose back-fin. Its head is wide and flattened with a big mouth surrounded by 4 pairs of barbels. Its back and sides are dark, often greenish-brown. Its belly is whitish. Potential productivity: Average weight of 4-10 kg adult. Annual productivity of 100 kg per ha (extensive) to 150 kg per m3 (intensive/ fish farming). It can be reared with Tilapia. Hardiness and Environment: Freshwater, tolerates lakes, ponds, rapid canals and rivers. It can absorb oxygen from air and from water; hence it is insensitive to changes in oxygen contents in water and tolerates low oxygen content.

D. Characteristic of *Limnothrissa miodon* (Isambaza)

	Description: Small fish of 10cm long (max 17cm for 40g) with a body covered with whitish scales. Potential productivity: Cannot be reared in fish farming. Its productivity depends on fishing. Seasonal fishing (near shore during rainy seasons, with peak in May-June and December-January) Hardiness and Environment: Freshwater fish living in Tanganyika like and Kivu lake, between 20 and 40m deep.

	Temperature tolerance: 21°C to

E.Characteristic of Protopterus aethiopicus

	**Description:** Elongate and cylindrical fish, 1.30m long (max 2 m long), soft-bodied, thin and cylindrical covered by scales. The tail is pointed, with long back and anal fins. The color is marble dark gray on the top and dark yellowish own. Potential productivity: Deriving from fishery only and not much marketed. Hardiness and environment: Lives into the rivers and lakes of East Africa. Temperature tolerance: 25°C - 30°C.

F.Characteristic of Haplochromis sp. (indugu)

	**Description** Small fish (8-10 cm), thin body, mainly blackish, but sometimes very colorful. This fish also has scales. Deriving from fishery only and not much marketed. Hardiness and environment: Lives into the rivers and lakes of East Africa. Temperature tolerance: 21°C - 27°C.

G. Lamprichthys tanganicanus (Rwanda rushya)

	**Description** **Origin:** Lake Tanganyika endemic **Size:** Males up to 15cm/6" in length. Females smaller. **Water:** pH 8-8.5, temperature 23-25°C **Diet:** Feed a mix of mainly live and frozen foods, including Mysis, Artemia and mosquito larvae. Some dry foods, like flake, will also be taken.

LO 1.3 – Choose fish species for culture

- Content/Topic 1: Selection criteria

A. The following criteria should be considered before selecting a fish for farming purpose:

A.1.Rate of growth: Fish which grow to a larger size in shorter period are suitable for culture. Eg. Carps.

A.2.Adaptation to climate: The cultured species of fish should be able to adapt to the local climatic conditions of the farm.

A.3.Tolerance: The fish should have the capacity to tolerate wide fluctuations in the physic-chemical conditions such as oxygen, salinity, and temperature of the water.

A.4.Acceptance of artificial feed: When more number of fish is to be accommodated in a limited space, there is the need for supplementary feeding on compounded diets. The fish should show ready preference for these feeds.

A.5.Resistance: It is desirable that the cultured fish is hardly enough to resist the common diseases and attack of parasites.

A.6.Amiability and compatibility: The fishes proposed to be cultured together ('poly culture') should be able to live together without interfering or attacking the other.

A.7.Conversion efficiency: The species of fish which give more edible flesh per unit of food consumed is preferred.

A.7.Consumer's preference: Food preference of people varies with the geographic regions. Hence, the species cultured should be easily marketable locally or to the targeted consumers.

A.8.Farming systems :(Monoculture/, Polyculture)

Learning Unit 2 – Construct a fish farming enclosures

LO 2.1 – Identify fish farming types

- Content/Topic 1: Fish farming types

Types of fish farming

A. Caging system

Fish cages are placed in lakes, bayous, ponds, rivers, or oceans to contain and protect fish until they can be harvested. The method is also called "off-shore cultivation. When the cages are placed in the sea. They can

be constructed of a wide variety of components. Fish are stocked in cages, artificially fed, and harvested when they reach market size. A few advantages of fish farming with cages are that many types of waters can be used (rivers, lakes, filled quarries, etc.), many types of fish can be raised, and fish farming can co-exist with sport fishing and other water uses.

B. Ponds

These use irrigation ditches or farm ponds to raise fish. The basic requirement is to have a ditch or pond that retains water, possibly with an above-ground irrigation system using this method, water allotments can be stored in ponds or ditches, usually lined with bentonites clay. In small systems, the fish are often fed commercial fish food, and their waste products can help fertilize the fields. In larger ponds, the pond grows water plants and algae as fish food. Some of the most successful ponds grow introduced strains of plants, as well as introduced strains of fish. Control of water quality is crucial. Fertilizing, clarifying, and pH control of the water can increase yields substantially, as long as eutrophication is prevented and oxygen levels stay high. Yields can be low if the fish grow ill from electrolyte stress.

C. Fish tanks

Culture of fish in tanks is mainly in intensive re-circulated and flow-through systems although tanks could also be used as small aquaria for ornamental fishes. In an intensive system, fish are grown at high density under tightly controlled environmental conditions. The water in the system is continually used in fish tanks filtered and recycled. Re-circulation systems require good management and a reliable source of energy to pump the water. The Tank shapes may be square, rectangular, circular or oval.

D. Race ways:

A raceway, also known as a flow-through system, is an artificial channel used in aquaculture to culture aquatic organisms. Raceway systems are among the earliest methods used for inland aquaculture. A raceway usually consists of rectangular basins or canals constructed of concrete and equipped with an inlet and outlet. A continuous water flow-through is maintained to provide the required level of water quality, which allows animals to be cultured at higher densities within the raceway. cultured in raceways are also used for some marine species which need a constant water

Figure 8: race way

E. Recirculating system

A recirculating system also referred to as water use system, water from rearing units is filtered and used again. Since fish live in water, obtain feed from water and discharge wastes into the same water, it is important that high quality standards are maintained. This, in recirculation systems, can only be achieved if

efficient filtration components are installed. Water filtration entails removal of particles and dissolved compounds such as ammonia from the water. In some operations filtration includes degassing, aeration and disinfection mainly with Ultra Violate (UV) radiation

LO 2.2 – Select fish farming enclosures site

- Content/Topic 1: Fish farming enclosures and site selection criteria for fish pond

A. Fish farming enclosures are:

A.1.Fish ponds: a pond is a shallow depression where water is confined.it can be either earthen, concrete or plastic-lined. A fish pond should be sited and constructed in a way that a farmer can control its water levels. **The water can be Static freshwater ponds**; Ordinary fresh water fish culture ponds are still-water ponds. They vary a great deal in water spread area and depth. Some are seasonal and some perennial. The ponds may be rain fed (also called sky ponds) and/or may have inlet and outlet systems. The water supply may be from a stream or a canal or from an underground source such as wells, tube wells. **Brackish water ponds**, not only are the species different from those cultured in freshwater ponds but the principle of operation of brackish water ponds is different from those of freshwater ponds. Here the pond or the farm is essentially located on a tidal creek or stream and there is a system of sluices to control the ingress and egress of water into and from the ponds**.**

A.2.Cages: In cage culture, fish is raised in enclosures suspended or fixed in water. Water from outside and inside the cage easily mix and exchange due to water current.

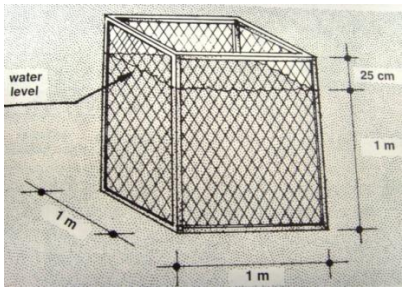


Figure 9: Fish floating cage

A.3.Tanks: Culture of fish in tanks is mainly in intensive re-circulated and flow-through systems although tanks could also use as small aquaria for ornamental fishes

A.4.Hapas: Hapas are net bags usually made of nylon material.net material is sewn together into desired shape normally rectangular or square. Hapas are often used in holding fish especially fry, in earthen pond

B. Fish ponds site selection criteria

The most important physical factors for suitability of a site for establishing fish ponds include: topography, Water supply and Soil type

B.1.Topography

An area of open and flat land with a gentle slope that allows water to flow by gravity is ideal. Any land surface that is not flat increases the cost of construction. A slope of about 1% is considered ideal. The area should not be prone to flooding. The area should not be subject to pollution in runoff from adjacent land.

B.2.Water supply

The most common sources of water used for aquaculture are surface waters (streams, springs, lakes) and groundwater (wells, aquifers). Of these, wells and springs are generally preferred for their consistently high water quality. The quantity and quality of water should be adequate to support production through seasonal fluctuations.

B.3.The quality of water

The various water sources may have strong bearing on the quality of the water for growing fish.

- Water from swamps may contain a lot of red iron. The iron may form a thick brown film on the surface of the pond. The film prevents light penetration and light is required for processes that promote pond productivity. Such ponds are not very productive and fish grows slowly.
- Water flowing from bare grounds with no vegetation cover, may carry a lot of silt. The silt suspended in the water may shade off sunlight and prevent the processes that make the pond Leave some distance from the swamp to the ponds to allow the grass to filter the water.
- Water flowing from swamps or a lot of rotting vegetation and other materials tends to contain acid levels that are not suitable for fish. White builders' lime is used to reduce the acid levels of water productive.

✓ **The following are solutions**:

- Vegetation in the streams filters the water to remove both the red Iron.it is recommended that the vegetation should not be cleared
- The use of the water upstream may also pose water quality risks for the pond.

Examples:

Garages may be disposing old engine oil into the stream that may find its way into the pond to kill fish.

Upstream communities may be washing or bathing in the water.

Untreated or insufficiently treated sewage may be deposited into the stream.

B.4.Soil type

Land should be comprised of good quality soil, with little or no gravel or rocks either on the surface or mixed in. Areas with rocky, gravelly, or sandy soil are not suitable for pond construction. The soil should be deep, extending down at least 1 meter below the surface. There should not be layers of rock lying close to the surface. Soils in the area where ponds will be built should have clay layers somewhere below the surface to prevent downward seepage. Soil that will be used to build the dykes must contain at least20% clay so the finished pond will hold water throughout the growing period. Some soil with higher clay content preferably between 30-40% should be available nearby. It will be used to pack the core trenches in the dykes.

B.5.Proximity to a market

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

B.6.Infrastructures

Are the roads good enough to bring supplies to the farm and take the product to the market? Are telephone service and electrical power available at the site? If an intensive production system is necessary due to constraints of space or water, access to power is a must. Telephone service may be needed for ordering supplies, arranging marketing or requesting technical assistance.

B.7.Availability of needed inputs

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

B.8.Personnel

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

B.9.Access to Technical Advice

Be sure good technical advice is readily available. Local extension agents or trained consultants are good possibilities. Remember: technical advice can be expensive and is sometimes wrong. Double-check advice received with a qualified individual (meaning they have produced a few tons of fish before) who is sincerely interested in your success. Good consultants admit when they don't know the needed information.

Consider both criticism and compliments very carefully: The best advice may come in the form of criticism, and compliments can be misleading. Horticulture and animal husbandry consultants may know about business planning for agriculture but probably do not know enough about fish farming to give proper technical advice.

B.10.Competition

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

B.11.Legal issues

Consider whether or not there are any legal issues that will affect your ability to culture fish at this site.

- Content /Topic2: Cage site selection criteria

A. Cage site selection criteria are:

A1.Water currents

This site must have sufficient water currents. This is very important in cage culture. Sites with strong water currents are not recommended for cage siting. Water currents ensure that wastes from the cage are washed out of the cage while at the same time allowing replenishment of the cage with clean water from the surroundings.

If several cages are to be placed in a water body, they should be placed perpendicular to the direction of the current so that water from one does not flow into another. This arrangement protects the cages from getting contaminated with wastes that could move from one cage to another.

A2.Water depth

A cage should be sited where the water depth is that is at least 3 meters. The bottom of the cage must never touch the water bed. If the water is too deep, anchoring becomes problematic. If the water is too shallow and the bottom of the cage is very close to the water bottom, the exchange of water may be seriously affected thus resulting in the poor growth and in some species into early breeding. The water bed at the site of the cages should be rocky. Muddy bottom surfaces are not good because of decomposition and possible emission of toxic gases from such areas.

LO 2.3 – Sketch and construct fish pond

Content/Topic 1: The main characteristics of a fish pond

The main characteristics of a fish pond are listed below:

Table 1: characteristic of fish pond

Location	Select land with a gentle slope and layout ponds to take advantage of existing land contours.
Construction	Ponds may be dug into the ground, they may be partly above and partly in the ground, or they may be below original ground level; slopes and bottom should be well packed during construction to prevent erosion and seepage; soil should contain a minimum of 25% clay. Rocks, grass, branches and other undesirable objects Should be eliminated from the dikes.
Pond depth	Depth should be 0.5-1.0 m at shallow end, sloping to 1.5-2.0 m at the drain end; deeper ponds may be required in northern regions Where the threat of winter-kill below deep ice cover exists.
Configuration	Best shape for ponds is rectangular or square.
Side slopes	Construct ponds with 2:1 or 3:1 slopes on all sides
Drain	Gate valves, baffle boards or tilt-over stand pipes should be provided; draining should take no more than 3 days.
Inflow lines	Inflow lines should be of sufficient capacity to fill each pond within 3days; if surface water is used, the incoming water should be filtered to remove undesirable plants or animals
Total water volume	Sufficient water should be available to fill all ponds on the farm within a few weeks and to keep them full throughout the growing season.

Dikes	Dikes should be sufficiently wide to mow; road dikes should be made of gravel; grass should be planted on all dikes.
Orientation	Situate ponds properly to take advantage of water mixing by the wind, or in areas where wind causes extensive wave erosion of dikes, place long sides of pond at right angles to the prevailing wind; use hedge or tree wind breaks when necessary.

- Content/Topic 2: Classification of fish ponds

Ponds can be classified according to:

1. **Origin,**
2. **Use of the pond,**
3. **Layout,**
4. **building materials and**
5. **water supply**

1. According to origin of fish pond

A. Types of diversion ponds

Diversion ponds are made by bringing water from another source to the pond. There are different types of diversion ponds

A.1.Embankment ponds

The dikes of an embankment pond are built above ground level. A disadvantage of this type of pond is that you may need a pump to fill the pond

Figure 10: Embankment pond

A.2.Excavated ponds

An excavated pond is dug out of the soil. The disadvantage of this type is that you need a pump to drain the pond.

Figure 11: Excavated pond

A.3.Partially excavated ponds with low dikes

Soil from digging out the pond is used to build the low dikes of the pond. The ideal site has a slight slope (1-2%) so the water supply channel can be constructed slightly above and the discharge channel slightly below the pond water level. Since natural gravity is used to fill and drain the ponds no pump is needed.

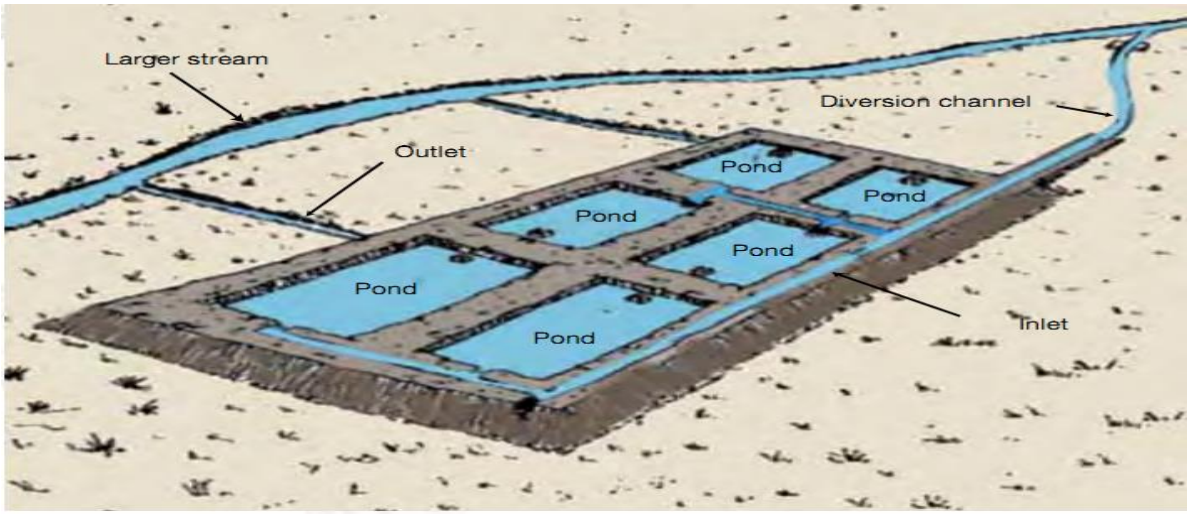


Figure 12: Partially excavated ponds with low dikes

B. Examples of diversion ponds

B.1.Barrage ponds

Are made by building a dike across a natural stream. The ponds are therefore like small conservation dams. The advantage of a barrage pond is that it is easy to construct. However, it is very difficult to control this system: it is difficult to keep wild fish out and a lot of food added to the pond will be lost because of the current. A properly built barrage pond (with overflow) overflows only under unusual circumstances.

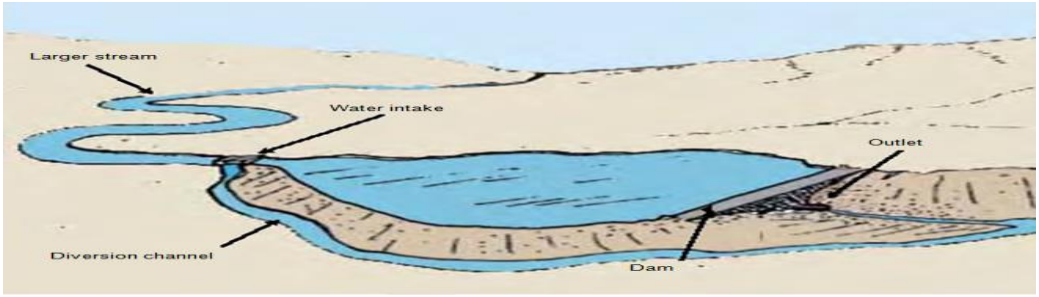


Figure 13: Barrage pond

2. According to the pond utilization (use of pond)

Ponds can be classified on the basis of their utilization such as, nursery pond, rearing pond, production pond, and breeding or spawning pond. While the nursery and spawning ponds are shallow, others are moderately deep. The optimum size, depth and use of the different ponds are given below.

A. Nursery pond

It is smaller (12 x 6 x 1m) and is mainly to nurse the hatchlings for a period of 2 or 3 weeks until they become fry (2.5-4cm). The depth of the water column may be between 1.0 and 1.5 m. The maximum stocking density of hatchlings is about 10 million/ha. Since these ponds are meant only for a short time, they could be used 2 or 3 times in a single breeding season. During the other seasons, the nurseries can also be used as productions ponds.

B. Rearing pond

It is fairly larger than nursery pond and has a size of 25 x12 x 1 m. Here, the fry are grown for about 2 months until they attain fingerlings stage (4 -10 cm). The depth of the water column may be between 1.5 and 2 m. when the rearing pond is not in use for rearing, it serves as a production pond.

C. Production pond

Here, the fingerlings are raised to marketable size fish. The size of this pond varies from 0.1 to 2.0 ha, as ponds larger than 2 ha are unsuitable for efficient management. The depth of the water column may be between 2 and 3 m. However, the economic size of production ponds depends mostly on the ecological conditions of the area and the type of fish culture

3. According to pond layout

When several ponds are being installed, they can be positioned in two ways:

A. Pond in a series

The ponds depend on each other for their water supply, as the water runs from the upper ponds to the lower ponds. This system has the advantage of limiting the number of draining and supply canals. However, since the same water is flowing through all of the ponds, there can be a problem with disease. Indeed, if a pond is contaminated, there is a higher risk that the others will become contaminated and all production will be lost. Draining the ponds will also be a problem.

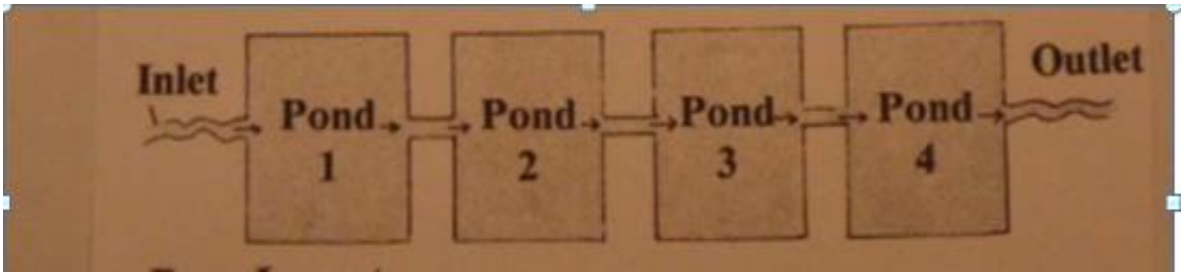


Figure 14: Pond arranged in series

B. Pond in parallel

Ponds in parallel arrangement are independent from each other, and each gets its supply of water directly from the supply canal. Water is not re-used after flowing through one pond. Unlike ponds in a series, each of these ponds can be isolated, and limiting the risk of contamination. Each pond is drained independently and the slope is the same for each.

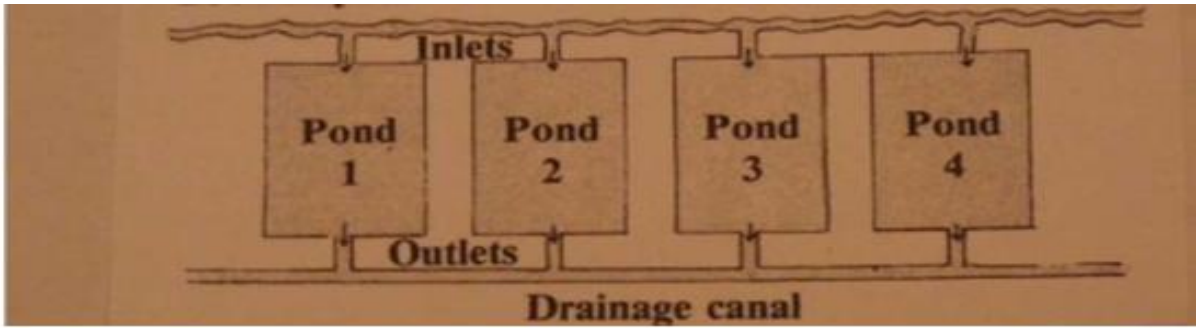


Figure 15: Pond arranged in parallel

4. According to construction material

The pond may be made by concrete or mud materials (earthen pond)

5. According to water supply

The fish ponds take water from various sources such as:

- Spring and bole holes water from under grounds
- Rain water run off (hill side ponds, storm reservoirs)
- Running surface water from stream, rivers (irrigation canals)

- Content /Topic3: Fish pond components and sketching

A. Fish pond

A fish pond is a shallow body of water, used for the controlled farming of fish. It is adapted to be easily and completely drained.

B. Component of fish pond

B.1. A plate

Plates form the bottom of the pond.

B.2.Dikes or bunds

Dikes surround the pond and form walls that contain the water. These walls must be solid, to resist water

pressure, and impermeable.

B.3. An intake structure

Intake structure helps to collect water to fill the pond.

B.4.The emissary

The emissary is a river or canal that allows for drainage.

B.5. Canals

Canals have role to bring or evacuate pond water

B.6. The supply canal or water inlet

Water inlet brings collected water to the pond.

B.7.The draining canal

These are drainage canal allows drainage toward the emissary.

B.8.Regulation devices

It is a device which controls the water's level, flow, or both:

B.9.The water inlet

It is the device that regulates water flowing toward the pond and stops water from flooding.

B.10.The water outlet

It is preferably a monk, controls the water level and evacuation of the pond.

B.11.The outfall or overflow

This allows evacuation of excess water, ensuring safety.

Filters, if necessary, prevent animals and particles from entering or exiting the pond

B.12.A fence

A fence surrounds the pond and keeps undesirable visitors out.

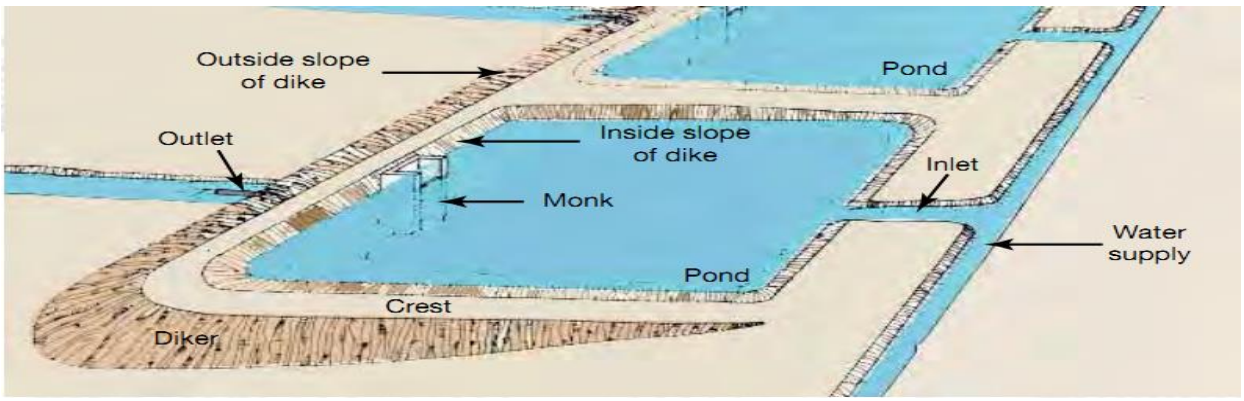
B.13. other structures

These provide protection against fish-eating birds, if necessary.

B.14.Access ways and roads

Roads surround the pond and allow people to reach it.

C. Pond sketching



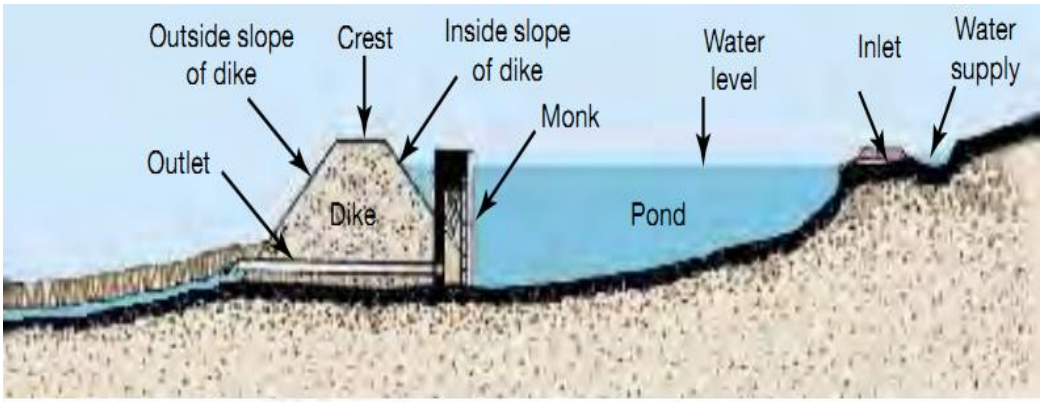


Figure 16: Cross section of a pond

- Content /Topic4: Identification of fish pond construction materials and equipment

The required materials for pond building include:

- ✓ Stakes,
- ✓ String and ropes,
- ✓ Decameter,
- ✓ Machete,
- ✓ Ledge hammer,
- ✓ Hoe ,
- ✓ Theodolite or automatic level,
- ✓ Paper and pencils,
- ✓ Planks of wood,
- ✓ PVC or galvanized iron pipe,
- ✓ Concrete,
- ✓ Sand,
- ✓ Gravel,
- ✓ Concrete-reinforcing steel,
- ✓ Paint.,
- ✓ shovel,
- ✓ pickaxe,
- ✓ wheelbarrow and/or basket,
- ✓ coupe-coupe,
- ✓ buckets,
- ✓ axe,
- ✓ heel bar,
- ✓ spade,
- ✓ roll of wire,
- ✓ Plumb level,
- ✓ compactor,
- ✓ hammer and
- ✓ saw

- Content /Topic5: Fish pond construction steps

1. Steps of fish pond construction

A. Prepare the site

First remove trees, bush and rocks and cut the grass in the area planned to build the pond. Then measure and stake out the length and width of the pond. The pond dikes will extend several meters above the ground level. In hilly areas, try to measure the slope of the land with a level or stick to find the best suitable site and orientation for the pond.

Remove the top layer of soil containing roots, leaves, etc. and deposit this outside the pond area. But save the topsoil for later use when grass is to be planted on the pond dikes

B .Build a clay core (in the case of contour ponds)

A clay core is the foundation for the pond dike which makes it strong and prevents water leaks. A clay core is needed in contour ponds and is built under those parts of the dike where the water will be above the original ground level. A clay core is not needed in dug out ponds because there the water level is below the original ground level.

Remove all the top soil in the area of the pond dikes and dig a 'core trench' in the same way as you would dig the foundation for a house.

The trench needs to be dug out along the lower side of the pond and halfway along each short side of the pond. Fill the trench with good clay soil. Add several inches of clay at a time and then compact it well. This will provide a strong foundation upon which the pond dikes can be built.

C. Dig the pond and build the dikes

Use the soil which you dug out when making the trench for the clay core to build up the dike on top of the core trench. Try not to use sandy/rocky soil or soil that contains any roots, grass, sticks or leaves.

These will decay later and leave a weak spot in the dike through which the water can leak out. Compact the soil often while you are building the dike. After adding each 30 cm of loose soil trample it down by foot while spraying water on the dike. Then pound it with your hoe, a heavy log, or a piece of wood attached to the end of a pole. This will make the dam strong.

The pond dikes should be about 30 cm above the water level in the pond. If catfish will be farmed in the pond, build the dike to 50 cm higher than the water level to prevent the catfish from jumping out.

The pond dikes should have a gentle slope. This makes them strong and prevents them from undercutting and collapsing into the pond.

The easiest way to slope the dikes is after digging out the main part of the pond. The best slope for the pond dike is one that rises 1 meter in height for every 2 meters in length. The pond bottom should also slope so the water varies in depth along its length. Smooth out the pond bottom after reaching the required pond depth. This makes it easy to use nets when harvesting the fish and they will slide easily over the pond bottom.

D. Build the water inlet and outlet

The water inlet consists of a canal to bring in the water, a silt catchment basin, and a pipe to carry water

into the pond. The water coming into the pond often contains a lot of soil and silt. This will make the pond very muddy. A silt catchment basin will stop this soil from entering the pond. Widen and deepen the inlet canal right outside of the pond dike. The soil will settle into this hole, called silt catchment basin, instead of entering the pond.

For a pond of 0.2 ha an inlet or outlet pipe of 15 cm diameter is ideal while for larger ponds (1 or 2 ha) the pipe or culverts should be around 25 cm diameter.

The water inlet pipe runs from the catchment basin through the pond dike into the pond.

It should be about 15 cm above the water level so the incoming water splashes down into the pond. This will prevent fish from escaping by swimming into the inlet pipe. It also helps to mix air (and thus oxygen) into the water.

The water outlet is an overflow pipe which is used only in emergencies. Water should not flow out of the ponds on a daily basis. During heavy rains the overflow pipe takes excess rainwater and run-off water out of the pond. The overflow pipe can be installed at an angle. Pipes should have screens to stop fish from entering or leaving the pond.

The **Inlet** pipe is screened at the edge which is outside the pond to stop wild fish and things like branches and leaves from entering.

The **Outlet** is screened inside the pond to stop fish from escaping.

E. Protect the pond dikes

When the pond dikes are finished, cover them with the topsoil that was saved when digging the pond. Plant grass such as Rhodes grass (*Chloris gayana*) or star grass (*Cynodon dactylon*) on the dikes. Do not use plants with long roots or trees because these will weaken the dikes and may cause leaks. The fertile topsoil will help the new grass to grow and the grass will help to protect the dikes from erosion.

F. Fence the pond

Putting a fence around the pond will protect children from falling into the pond and it can help keeping out of thieves and predatory animals. To make a low cost and sturdy fence, plant a thick hedge around the edge of the pond or build a fence using poles and thorn branches.

Learning Unit 3 – Stock fish farming enclosures

LO 3.1 – Prepare fish pond

- Content/Topic 1: Fish pond preparation

1. Steps to prepare the pond for stocking.

A. Drainage and drying

For an old pond**,** drain all water from the pond and allow it to dry for a period of fourteen days. Drying the pond bottom helps kill potentially harmful organisms in the soil and speeds the breakdown of excessive organic matter (a beneficial process) that remains after previous crops of fish.

B. Liming

A layer of lime (calcium hydroxide) is spread over the bottom, for 2 weeks. It removes the acidity of the soil, facilitates desirable geochemical cycles and kills unwanted soil organism. The dosage of quicklime depends on the pH of the pond soil.as shown in the table below.

Table 2: The dosage of quicklime depend on pH of the pond soil

PH	Nature of soil	Quantity of lime (Kg/ha)
4.5 – 5.0	Strong acidity	2000
5.0 – 6.5	Medium acidity	1000
6.5 – 7.5	Neutral	500
7.5 – 8.5	Medium alkalinity	200
8.5 – 9.5	Strong alkalinity	No application

C. Fertilization

After 15 days of liming, the fertilization is to be done in order to develop the fish food organisms (phytoplankton and zooplankton). Fertilizer may be of organic and inorganic nature.

C.1.Organic fertilization

Apply organic fertilizer to the pond before filling it with water. The most common examples of organic fertilizers are animal manures (e.g., from cattle, poultry, donkeys, rabbits, sheep, Goats) and decaying plant matter, such as cut grasses. The available animal manure should be applied to the fish pond at a rate of 50 g of dry matter per m^2 per week. This is equivalent to 5 kg/100m^2/week.

C.1.1.The manure can be applied to the pond in one of the following ways:

- Spread dry manure on the pond floor before filling with water.
- Spread (broadcast) dry manure on water surface periodically.
- Place dry manure in a crib or compost bin in a corner or along the side of the pond,
- Set sacks filled with manure to float within the pond and shake them daily to allow nutrients to leach out and enhance water fertility.
- Construct poultry houses or pig pens above or adjacent to ponds to facilitate easy movement of the manure to the fishpond.

C.1.2.The Plant matter use one of the following ways:

- Combine dead plant material with animal manure to form compost, which can then be applied into pond waters.

- These materials can also be mixed as compost heaps in cribs in a corner or along the side of the pond.
- Hay and other grasses can also be spread over the pond water as fertilizers.

D. Fill the pond with water.

Before filling the pond, put rocks on the pond bottom where the water will splash on when coming from the inlet pipe. This will keep the water from making a hole and eroding the pond bottom. Then open the inlet canal and fill the pond. Fill the pond slowly so that the dikes do not subside due to uneven wetting. While the pond is filling, the water depth can be measured with a stick. Stop filling the pond when the required depth is reached.

Do not fill the pond too full so it overflows. The overflow pipe is used to get rid of too much rain and run-off water. Water in the pond should not flow through (and thus be stagnant) as water flowing through the pond slows down fish growth by flushing away the naturally produced fish food. The only water added to the pond should be for the water losses due to evaporation and seepage.

E. Inorganic fertilization

Apply inorganic fertilizer to the pond after it has been filled. Inorganic fertilizers sometimes called "chemical" fertilizers are manufactured from mineral deposits for use in land agriculture.

Use of chemical fertilizers should vary according to the concentration of phosphorus and nitrogen in the soil. The standard combination of NPK as 18: 10: 4 is generally recommended for freshwater ponds. For a production pond of medium fertile soil; urea at the rate of 200kg/ha/year or ammonium sulphate at the rate of 450kg/ha/year, superphosphate at 250kg/ ha/year and Potassium chloride 40kg/ha/year should be applied in equal instalments, alternating with organic manure.

E.1.Methods of inorganic fertilizers application to the pond

Use one of the following;

- ✓ Dissolve the fertilizer in a bucket of water by stirring with a stick and then sprinkle the solution around pond.
- ✓ Place small mesh bags of fertilizer on platforms just under the water surface in the pond, where the material can slowly dissolve and become available to phytoplankton.
- ✓ Suspend small bags of fertilizer from stakes just under the water surface.

F. Water quality assessment in the pond

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

F.1.Dissolved Oxygen (DO)

The goal should be to keep DO at3 mg/L or higher for Fish by:

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

F.2.Plankton Turbidity

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

Fertilizing the pond at recommended rates prior to stocking and as needed during the fish production cycle, to maintain the plankton bloom.

Checking visibility frequently during the culture period and taking necessary actions before problems arise: In case of low visibility, physically remove excess plankton. If visibility is high, apply additional fertilizer.

A **Secchi disk** is used to estimate phytoplankton density and the fertility of a pond. If you can still see the disk when it is lowered beyond 45 cm, then the pond should be fertilized. If the disk disappears at a depth much less than30 cm, then the pond is too fertile.

F.3. pH

The p^H of pond waters should be maintained between the optimum limits for fish, i.e., between 6.5 and 9.0. This can be achieved by, maintaining alkalinity at or above 40 mg $CaCO_3$/L, so that pH does not fluctuate widely and applying lime (agricultural limestone) to the pond soil at recommended rates in regions where water and soils are acidic.

F.4.Water Temperature

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

Stocking species whose optimum temperature ranges match the temperature of the water available at your location.

If sources of water with different temperatures are available, adjusting pond water temperatures by adding cooler water to lower the temperature

LO 3.2 – Handle and transport fingerlings

- Content/Topic 1: Quality control of animal products Transport conditions and techniques

A. Young fish is delicate and must be handled with care.

As a rule:

- Fish must not be held out of water for a long time.
- Fish seed can be harvested from a pond, tank or Hapas depending on the production system.
- Regardless of the system, fish seed should not be stressed.

B. Guidelines for safe handling of fingerlings

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

- Content/Topic 2: Transport facilities

1. **Transporting the Fingerlings**

If the hatchery supplying the fingerlings is a long distance away by road or on another island, the supplier will need to carefully prepare and package the fingerlings for transportation.

In east Africa fish seed is transported in various ways including polyethene bags and tanks. Fish fry or fingerling to be transported are kept in a holding tank and not fed for 12 hours prior to transportation.

Polyethene bags are tied with a rubber band at one end. In general, bags should include 1/3 water for 2/3 air or oxygen. The seed from the holding tank is placed in the bags and oxygen infused into the bags. The bags are sealed off by tying with rubber band. The bags filled with fish are place horizontally into a wooden or paper box ready for transportation.

Fish can also be transported in a plastic tank half filled with water with oxygen infusing into the water from cylinder. Transportation should be done during cool weather. It is advisable to add 5-8g/L of table salt (sodium chloride) in the water in which the fish is being transported to minimize stress.

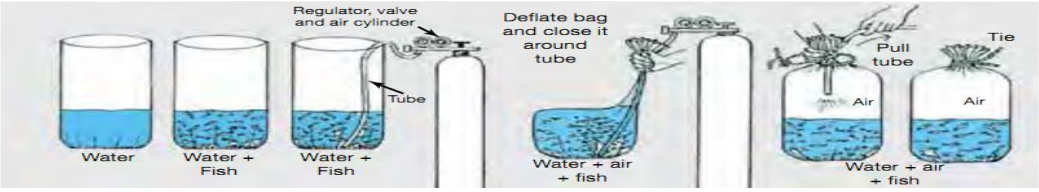


Figure 17: Packing fish in plastic bag

Figure 18: Transportation of fingerlings by tank

NOTE Place the containers in the dark and keep them safe from sudden noises in order to keep the Fish quiet during transport, Fish should be kept cool during transport, do not feed fish during transport and If a fish dies in a bag or a container, it should be removed quickly. After transport and before the fish are released into the water, the container should be placed in the new water to equilibrate the temperature between the water in the bag and the water in the pond.

LO 3.3 – Stock fish farming enclosures

- Content/Topic 1: Stocking criteria

A. Stocking

On arrival at the place where the seed is to be stocked, the water where the fish is to be stocked is slowly mixed with the one in the transporting container to acclimatize the fish and avoid temperature shock.

Fish seed must be allowed to swim by themselves out of the transportation container into the new rearing facility. After the seed have swum out of the container they should be observed for at least 30minutes.If there are any dead ones they should be removed and recorded. Observation of seed in the new rearing

facility should continue daily and for not less than seven days, following which regular sampling should be done till harvest.

Note: The newly stocked seed is prone to predation and measures should, therefore, be put in place to avoid it. Feeding of the newly stocked fish should start 12hours after stocking.

B. Stocking criteria

The main criteria to be considered in fish stocking are the following:

- ✓ Size of enclosure,
- ✓ Species of fish,
- ✓ Quality of water,
- ✓ Feeding capacity
- ✓ Type of production

- Content/Topic 2: Fish stocking densities

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

A. Fish stocking density

Table 3: Fish stocking densities according to fish species

Fish Species	Stocking density (/m^2)
Tilapia sp	1-2 Fish
Clarias gariepinus (African catfish :Inshonzi)	2 – 5Fish
Cyprinus carpio (Common carp: Inkuyu)	5-20Fish

B. Guidelines for stocking fish from bags

The following are the recommended steps to follow when stocking fish into ponds from bags.

- Do not open any of the bags before they get to the pond. This is because once a bag is opened, all the oxygen in the bag will leave into the atmosphere. The fish only have about 5 to 10 minutes before they run out of oxygen after a bag has been opened.

- Set the bags right next to the pond (keep bags in basket or box to support the bag) or just in the pond. You are going to add water to the bag, so it may be too heavy to move after that. Check the water quality parameters of the pond before opening the bags and the water quality within the bags as well as during the course of acclimation, especially for temperature and oxygen.
- Open one bag at a time. Begin with the bag that is least inflated. If you have no tools for checking water quality, use your fingers to detect for any obvious temperature differences between the pond water and water in the bag.
- Add water from the pond into the bag. While doing this, you can allow the other un-opened bags to float on the pond. This will allow the other bags to adjust to the pond temperature. Cover these bags to shade and prevent excessive sunlight.

Note: Floating the un-opened bags on ponds alone is insufficient to acclimate the fish properly. This is because bags used for packing fish for grow-out ponds are large and the bag often contains much more fish unlike those used to pack ornamental fish for stocking aquaria.

- Add small amounts of water from the pond into the bag over 10 to 20 minutes to allow the temperature and water quality (e.g., pH) of the transported water to slowly become similar to that of the pond water.
- The total amount of water added should be double or triple the amount already in the bag.
- Then lower the bag in the pond and tip it so that the fish can swim out on their own. Observe how they swim out.

Note: Pouring fish from a bag or throwing them into the pond can be stressful. It is best to let them swim out of a bag or out of a net by themselves. In some countries, lakes are indeed stocked by dropping the fish from airplanes, but survival is not reported.

C. Guidelines for stocking from transport tanks/ containers

- Drive down as close as possible to the pond.
- Check the water quality in the pond and in the tank.
- With a bucket, remove about a third of the water in the tank. Then add pond water. Repeat this process 2 times giving time for the parameters to gradually re-adjust as mentioned in 4.6 above.
- Scoop out a few fish at a time into a bucket with adequate water using a scoop net.
- Gently lower bucket in water and let fish swim out on their own

Note: Keep the aeration going in the tank right through the process until all the fish have been stocked.

It is important to stay around and observe how the fish swim out of the bag or container. Any fish that lie immediately on the pond bottom will likely die within a day or two. Fish that swim erratically or have any discoloration on their bodies or fins may die within 2 to 4 days. If the fish swim back into the container, it is probably due to the fact that the water current has reversed (fish swim against the current). Be around to ensure no birds take the fish during stocking or soon after.

Learning Unit 4 – Manage fish production

LO 4.1 – Describe fish farming systems

- Content/Topic 1: Fish farming systems

Fish farming may range from large scale industrial enterprises to 'backyard' subsistence ponds. Farming systems can be distinguished in terms of input levels

1. Extensive

2. Semi-intensive

3. Intensive

4. Fish farming

1. Extensive fish farming

Extensive fish farming (economic) inputs are usually low. Natural food production plays a very important role, and pond productivity is relatively low. Fertilizer may be used to increase pond fertility and thus fish production.

2. **Semi-intensive**

Semi-intensive fish farming a moderate level of inputs is used and fish production is increased by the use of fertilizer and/or supplementary feeding. This means higher labour and food costs but higher fish yields more than compensate for this usually.

3. Intensive fish farming

Intensive fish farming is a high level of inputs is used and the ponds are stocked with as many fish as possible. The fish are fed supplementary food, and natural food production plays a minor role. In this system the high feeding costs and risks, due to high fish stocking densities and thus increased susceptibility to diseases and dissolved oxygen shortage, can become difficult management problems. Because of the high production costs, you are forced to fetch a high market price in order to make the fish farming economically feasible.

4. Integrated fish farming

Integrated fish farming, is the linking of fish farming operations with the entire crops and animal farming systems in order to take advantages of all potential resources of the system.

A. Integrated fish farming is characterized by the:

- Integrated management of fishery, animal and crop production

- Utility system and cycling of agricultural products, by-products. Waste material or other resources on a farm.
- Culture of multi-species of fish and other aquatic animals.

B. Monoculture and Polyculture

In monoculture only one fish species is raised in the pond. An advantage of monoculture is that it is easier to give certain supplementary foods to the fish as there is only one fish species to consider with regard to food preference.

A disadvantage is the risk that a single disease may kill all fish in the pond as different fish species are usually susceptible to different diseases.

C. Polyculture

In Polyculture more than one fish species is raised in the fish pond. In this way the various natural food resources in the pond are better utilized. Each fish species has certain food preferences which are related to the position of the fish in the pond (e.g. bottom-living or mid-water-living fish).

For example, mud carp live mostly on the bottom of the pond and feed on mud and dead material which they find on the bottom. Tilapia, on the other hand, live more in the deeper part or end of the pond; some species feed on plants and others on plankton. By combining different species in the same pond, the total fish production can be raised to a higher level than would be possible with only one species or even with the different species separately.

LO 4.2 – Rear fish

- Content/Topic 1: General conditions for fish rearing

1. Rearing conditions for farmed fish

Fish farming takes several different forms, some more intensive than others. Methods vary in how the fish are held, how the water is managed and the level of feed inputs. A review of the welfare issues in global aquaculture is given in *Animal Welfare and Meat Production*[1].

A. Some key welfare issues concerning rearing conditions for farmed fish are broadly summarized below:

A.1.High stocking density (leading to poor water quality (lack of oxygen, build-up of ammonia), crowding, increased susceptibility to disease and parasites)

A.2.Social stresses (aggression leading to chronic stress and injury such as fin erosion, competition for food, cannibalism)

A.3.Other environmental stresses (inappropriate temperature/salinity, insufficient hiding places/cover/protection, cage noise).

Fish confined in cages or ponds are unable to escape causes of fear and distress, such as low oxygen, cage noise generated in rough weather by the impact of waves and aggression from larger fish which can lead to injury, inability to feed and cannibalism. Crowding fish together encourages the spread of disease and of parasites, which are a common cause of irritation. Sea lice feed on the skin and blood or fish, leading to ulceration, reduced growth and sometimes open wounds on the back of the head.

Besides cannibalism and parasites, farmed fish can also be attacked by external predators (such as birds, seals, jellyfish).In some types of fish farming, fish such as tilapia are stocked together with predator fish to control numbers.

B. Fish handling procedures, such as transferring fish between pens; grading (separating fish by size); vaccination by injection and chemical treatments to prevent disease/parasites, are further sources of stress which can result in injury that may lead to fatal infection.

Figure 19: Wild rainbow trout.

C. Breeding and genetics

An animal's internal environment can be harmed not just by the environmental rearing conditions but also by its own genetics – i.e. how the animal has been bred. Fish welfare issues include selective breeding for fast growth, genetically modified transgenic fish and triploid fish.

Selective breeding for fast growth has created serious health and welfare for terrestrial farmed animals, and therefore presents the risk of similar welfare problems being developed in farmed fish.

D. Suitability for farming

Some fish species may be unsuitable for farming. For example, eels are a solitary animal much of their lives. Under farm conditions, the dominant individuals are "feeders" and continue to grow whereas subordinates become "non feeders" and show signs of stress such as gastric ulcers, and there are frequent confrontations between them.

The farming of carnivorous species, such as salmon and trout, has also attracted controversy on account of their requirement to consume, as feed, more fish (in the form of fish oil and fishmeal) than they produce.

- Content/Topic 2: Fish feeding

The objective of feeding fish is to provide the nutritional requirements for good health, optimum growth, optimum yield and minimum waste within reasonable cost so as to optimize profits.

A. Classification of feeds

There are two main categories of fish feed which the fish can eat to grow: naturally produced fish food inside the pond and artificial fish food supplied from outside the pond to the fish.

A.1.Natural food

Is the feed that fish eats in the environment these are living organisms produced in the water where the fish live. The type of natural food varies but is composed of tiny organisms (plankton); which may be plants

(Phytoplankton) or Animal (zooplankton), visible only under a microscope. Newly-hatched fish require zooplankton for the first few days of feeding. These tiny animals can be cultured and used to feed fish, especially the newly hatched fry.

A.2.Artificial feeds

Artificial feed can be in the form of single ingredient like groundnut oil cake or rice bran or silk warm pupae etc.

Mixture of different ingredients like trash fish and slaughter house wastes Simple mixtures of powdered ingredients. Ingredients compounded into dough (pâte) or pellet forms. When supplementary food is given to the fish most of it is directly eaten by the fish.

The uneaten food will act as an additional fertilizer for the pond. But even in ponds receiving a high amount of supplemented food, natural fish food still plays a very important role in the growth of fish.

B. Qualities of good feed

The quality of feed refers to the nutritional as well as the physical characteristics of the feed that allow it to be consumed and digested by the fish. The feed must have the following qualities:

Balanced nutrients, Nutrients in the feed must be adequately stable in water; Feed should have required attractants, stimulants, etc. so that the feed will be taken by fish immediately before it becomes waste in water. Size and shape of feed like granules, pellets must be in a form which can be easily handled by the fish. And Preparation of feed should not produce any unfavorable environmental effects

C. Estimating the Correct Amount to Feed

The amount of feed required per ration can be estimated with the help of a feeding chart and calculated as follows:

Amount of required feed=Average fish size (weight) x Feed rate (%) x Total number of fish in the pond

Where,

The feed rate is the amount recommended in the feeding chart as a percentage of the fish's average weight at that time.

C.1.Examples on Calculating the Daily Feed *Ration*

i) If an African catfish of 5 grams requires a ratio of 8% of its body weight, how much food should it be given per day?

Amount of feed to be fed per day = 5 grams x 8/100= 0.4 grams feed per fish per day.

If there are 1000 fish in the pond, then:= 0.4 g x 1000 fish = 400 g of feed should be weighed out for the day

Note According to the feeding chart, the fish should be receiving 2 meals a day. Feed about 2.25 grams of feed at each meal. But because water temperatures are normally

D. Feed Conversion Ratio (FCR)

The Feed Conversion Ratio (FCR) is the amount of food required to produce a unit of fish).

It is an indicator of the:

- Performance of a feed
- Performance of the person feeding the fish and the fish's health
- Cost-effectiveness of using a particular feed. **FCR=**Total amount of food given kg/Total amount of fish produced kg

D.1.Example on How to Calculate FCR and use FCR to Assess Returns to Feed

If at the end of a production cycle, a total of 150 kg of fish are harvested from a pond and a total of 200 kg of feed was fed to the fish during production, how much feed was required (used) to produce each kilogram of fish harvested?

The FCR will be:200ckg (total amount of feed fed during production)/(150kg fish harvested-10kg fish stocked)=1.4
This means a total of 1.4 kg of feed was used to produce each kilogram of fish.
In grow-out operations, a good FCR should be between 1.5 and 2 when using the pellets currently available on the market. The FCR should never be above 2. Having it equal to 2 means 2 kg of feed is used to produce a kilogram of fish.

D.2.A feed conversion above 2 is poor and arises when:

- Poor quality feed is fed. This occurs when feed is of poor nutritional value or the pellet is of poor physical quality.
- The feed (size or nutritional quality) given is not suitable for the age of fish being grown. For example, the pellet may either be too big or too small, contain nutrients in the wrong proportions, etc.
- The culture conditions are stressful to the fish. For example, if dissolved oxygen levels are continuously below 1 mg/l and/or ammonia levels are high (>20 mg/l), as commonly occurs when ponds have attained their carrying capacity.
- Fish are 'over-fed'.
- Survival rates at harvest are low. Low survival rates may arise as a result of stocking small sizes, poor handling at stocking, predation, etc.
- Feeding for growth when the pond is at its carrying capacity.

E. Nutritional requirements in feed

Proteins – 20 to 60% required for optimum growth
Amino acid – 10 to 15 grams per Kg of feed is required
Fats – 4 to 18 % is required
Carbohydrates – 10 - 50% is required
Vitamins – A, K, E – for growth maturity
D – for growth promoting effect of fish

Combination of moist diet

Table 4: Nutritive values of feed ingredients

Ingredient	Percentage
Fish meal	35%
Rice bran	20%
Soy bean meal	15%
Corn meal	10%
Leaf meal	3%
Squid Oil (or fish oil)	7%
Starch	8%

Vitamin mix	2%

- Content /Topic3: Conduct fish reproduction

1. Types of reproduction

A. Natural reproduction

B. Artificial reproduction

A. Natural reproduction

Although fish breed frequently in unmanaged ponds, the small number of fry they produce means that fish farms need to invest in systems for fry and fingerling production. The systems used are ponds, net enclosures (Hapas), and tanks. Breeding systems depend on the natural behavior of the fish.

A.1.Brood stock selection

Select quality brood stock to improve fish production on the farm. During Brood stock selection, the following points should have considered:

- ✓ Choose pure quality stocks and do not allow them to cross breed with other strains to preserve their genetic quality.
- ✓ Initially you may have to collect the bloodstocks from the wild, whereas later you can select them from your own ponds or purchase them from other farmers.
- ✓ If buying the fish stocks from others buy them only from reliable and established sources and avoid introducing breeders from no accredited sources.
- ✓ Use brood fish that are mature but not too old; for catfish and tilapia they should be at least one-year-old but not more than three years old (> 100 g for tilapia and between 0.5 and 1.0 kg for catfish)
- ✓ By using larger brood fish, you can easily identify the original stock after each production cycle.
- ✓ You can use the same stock repeatedly, depending on their performance, but should adopt a culling/selection process to eliminate undesirable stock.
- ✓ Always eliminate fish that have questionable characteristics by examining breeders carefully when re-stocking after each cycle.

A.2.Stocking brood fish (sexing and sex-ratio

- **Hand Sexing**

Sexual features distinguishing males from females are clear when fish mature, which occurs at about 10 cm. Males, have two orifices situated near the ventral (anal) fin. One is the urogenital opening and the

other is the anus. Females have three orifices, the genital opening, the anus, and a urinary orifice which is difficult to see with the naked eye.

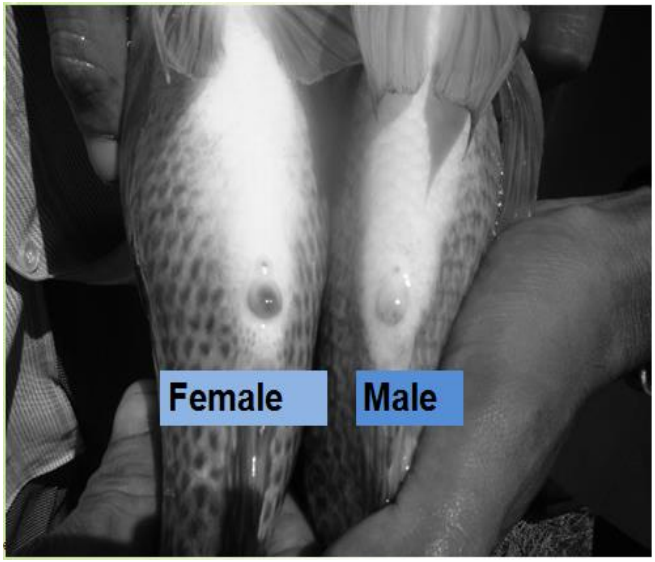


Figure 20 :identification of sex of fish

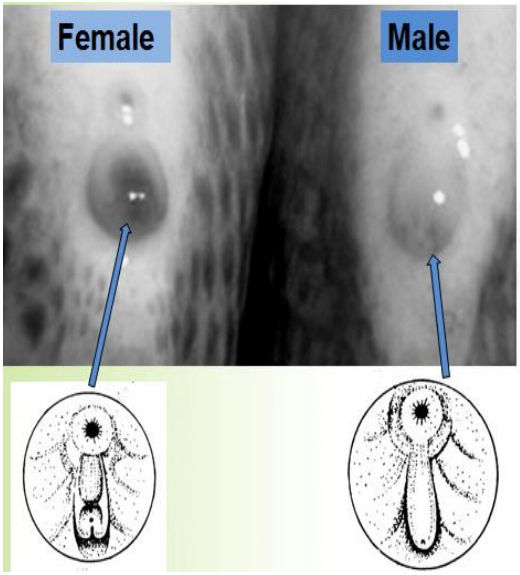


Figure 21:Fish sexing

- **Sex ratio**

Sex ratio depends on fish species and farming system**,** the best ratio is 1male to 2 or 3 females this, help to increase the chances of spawning, you might try raising the temperature in the breeding tank a few degrees. Once the fish have mated, watch the females for the telltale sign of pregnancy – the development of a dark "gravid" spot on the belly. When this spot becomes very dark, almost black, it is a sign that the fish will soon give birth.

- **Hormonal sex reversal**

A tank-based or Hapas-based (small cage net) hatchery is needed so that fry can be collected at the yolk sac or first feeding stages, no later than one week after they have been released from the female. Healthy fry of uniform size is transferred to the tank or hapa, where they are fed the hormone containing diet for a period of 21-28 days.

- **The method for preparing sex reversal feed**:

✓ Mix 30-70 mg of hormone (methyl or ethynyl testosterone) in 700ml of 95% ethanol
✓ Add 700 ml of hormone solution to each kg of finely ground feed.
✓ Mix thoroughly and dry.
✓ Add any supplements.
✓ Refrigerate (if the feed is not to be used immediately).
✓ Feed at a rate of 10-30% of body weight per day, at least four times a day, for 21-28 days.
✓ The fry must eat the feed containing the sex reversal hormone and no natural food.
✓ Feeding of Fry in Hapas
✓ The Fry reared in a Hapas must be fed on a daily basis.
✓ Feed fry a diet in powdered form at the rate of 5-10 percent of the total body weight per day.
✓ Divide the daily feed ration into four feedings per day until the fry reach the desired size (5g).

B. Artificial reproduction

B.1.Selection and handling of brooders

Capture and transport fish early in the morning or late in the evening when it is cool. Ice can be used to reduce sudden changes in water temperature. Anesthetics have also been used to reduce fish stress during transportation and transfer to tanks.

Handle the brood fish as little and as gently as possible to avoid stress. Damage to the slime (mucus) layer can lead to infection.

Use a seine to gently capture enough fish to be able to select sufficient males and females for spawning. After collection of the fish from the conditioning pond, disinfect them in a formalin bath to prevent the transfer of pathogens from fish to eggs and fry.

Selection involves separating males from females and checking for maturity. Do this by gently pressing the abdomen with the thumb; fecund females release shiny greenish eggs. Mature males cannot be stripped and can only be selected by their size.

Choose females of about 0.5 to 1.0 kg; this size has a substantial quantity of eggs and is easier to handle than larger fish.

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

B.2.Collecting and injecting the pituitary

To avoid temperature shock it is advisable to use a thermostat or heater where available.

Brooders should be held without food for 24-36 hours in a container at 25- 30°C prior to injection with pituitary. Pituitary can be collected from either male or female fish. For each female spawner, two pituitary donors of 500 g average weight are used.

When using fresh pituitary:

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

If the female has responded well, eggs will easily run out from the genital papilla when the belly is gently pressed.

Figure 22:Expressing eggs from a female rainbow trout

B.3.Stripping the female and fertilizing the eggs

- ✓ Gently strip eggs from the female into a dry bowl and estimate the number of eggs (One gram

contains about 600-700 eggs).

- ✓ Male gonads can be removed and macerated (mashed) and the milt mixed with eggs at the time of stripping the female.
- ✓ Squeeze the freshly dissected testes and distribute the milt droplets evenly.
- ✓ Immediately add some clean water to the bowl and mix eggs with the sperm by gentle swirling of the bowl.
- ✓ Use a feather to mix the eggs and milt.

B.4.Incubating the eggs

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

B.5.Larval rearing

Several factors are of great importance when nursing larvae:

- ✓ Start them out in a protected hatchery environment (rather than stocking them directly into ponds) to increase survival rates.
- ✓ Stock them at an appropriate density (about 100 larvae per liter) to get better growth and survival.

- ✓ Availing large quantities of zooplankton (for example, rotifers or Artemia) as starter feeds for the first 10-14 days helps increase growth and survival rates.
- ✓ Transfer the fry to Hapas (feed well with live and artificial feeds) or to a well-prepared (zooplankton-rich) nursery pond to increase survival.

B.6.Hatchery rearing

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

B.7.First feeding of larvae

- ✓ The larvae normally begin feeding on the second or third day after hatching, before the yolk sac is completely absorbed;
- ✓ Therefore, you must begin to feed them at this same time when rearing them in the hatchery.
- ✓ When they begin feeding, the larvae normally utilize live feeds and their systems are not sufficiently developed to utilize dry (manufactured) feeds;
- ✓ It is therefore recommended that dry feeds be supplemented with Artemia nauplii or rotifers during at least3 of the 10 to 12 daily feedings for the first three to four days of feeding.
- ✓ If an abundance of live food is available, maintain a constant concentration of live food organisms in the larval rearing system, as this greatly enhances their growth rate.
- ✓ It has been shown that a continual supply of food produces the highest growth rates; you should therefore feed the larvae as much as they will consume in about 15 minutes by hand every 2 or3 hours for 16 to 18 hours each day.

B.8.Predation on the larvae

One of the most serious predators in ponds is toad tadpoles. The presence of tadpoles is also a nuisance because they compete for food resources within the pond. Other predators include backswimmers, insect larvae, copepods, etc. It has been observed that predation pressure can be very high (100%

mortality) during the yolk-sac stage but decreases gradually as the larvae increase in size. It is therefore suggested that fry be transferred to nursing ponds only after they have reached a size greater than 10 mm to avoid losses to predation during the primary nursing phase

B.9.Transferring fry to nursery ponds

After approximately 14 days in hatchery tanks, the fry can be transferred to ponds. Ponds should be well prepared to receive the fry. This includes proper pond bottom drying between crops, liming when needed, and proper fertilization to develop abundant supplies of natural foods for the fry to be stocked. Where possible, use Hapas in ponds to further protect the fry and increase their growth and survival rates. For best results, totally cover the tops of the Hapas with cut grasses or other materials to provide the maximum possible amount of shade for the fry.

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

B.10.Factors contributing to the growth and survival fry

Factors that influence the growth and survival of fry include:

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

- Content/Topic 4: Perform integrated fish farming

1. Integrated fish farming

There are several systems of integrated fish farming. Integration can involve both animals (livestock) and crops in the system and, on a large scale, processing industries where fish farming benefits from by-products such as offal and blood being fed to the fish.

A. Fish-livestock Integration

The aim of livestock integration is to provide manure for the production process of food for fish. Most frequently animal waste is used to fertilize ponds which promote growth of planktons and other natural foods on which fish feed.

Fish such as African catfish may directly feed on uneaten poultry feed that end up in the litter. Such food would otherwise be lost if the manure were not utilized. Some fish use the fecal materials directly.

Further, in this system, drinking water for livestock can be drawn from large ponds and reservoirs where fish are reared.

Examples of livestock-fish integration:

- Fish- poultry farming integration
- Fish-pig farming integration
- Fish-cattle/goat farming integration
- Fish-other animals (rabbit, pigeon, etc.) farming integration

A.1.Fish-poultry integration

- ✓ **Fish- Duck farming integration**

It is highly profitable as it enhances the animal protein production in terms of fish and duck per unit area. Ducks are known as living manuring machines. The duck droppings contain 25% organic and 20% inorganic substances. Hence, it forms a very good source of fertilizer in fish ponds for the production of fish food organisms.

Besides manuring, ducks eradicate the unwanted insects, snails and their larvae which may be the vectors of fish pathogenic organisms.

For duck – fish culture, ducks may be periodically allowed freely, or may be put in screened resting places above the water. Ducks are reared in shelters built on the banks of the ponds or constructed over the ponds on stilts, or sometimes built on floating platforms. Shed made of bamboo splits may also be suspended in the pond to allow uniform manuring. The ducks stocked in these sheds at the rate of 15 to 20/m^2.

Depending on the growth rate of ducks, they replaced once in 2 to 3 months. Above 15-20 days old ducklings are generally selected. The number of ducks may be between 100 and 3000/ha depending on the duration of fish culture and the manure requirements. For culturing fish with ducks, it is advisable to release fish fingerlings of more than 10cm size; otherwise the ducks may feed on the fingerlings. The stocking density of fingerlings also depends on the size of pond and number of ducks released in it. As nitrogen- rich duck manure enhances both phyto and zooplankton production. Under stocking density of 20,000/ha and culture period of 90 days, a fish production of 2,000 kg/ha has been obtained in duck – fish culture. In the Central African Republic, ponds stocked with *O. niloticus* (20,000 fingerlings/ha) and *Clarias*

gariepinus (100 fingerlings/ha), combined with 1,500 Peking ducks/ha have produced 3.8–4.5 t of fish/ha/year and between 4–6 t/ha/year (live weight) of ducks.

- ✓ **Fish-Chicken farming integration**

The droppings of chicks rich in nitrogen and phosphorus would fertilize fish ponds. Poultry housing, when constructed above the water level using bamboo poles would fertilize fish pond directly.

Fish production of 10 t/ha could be obtained by culturing tilapia with a stocking density of 20,000 fingerlings/ha and chicken density of 4,000/ha. No chemical fertilizers or supplemental feeds have to be given at any stage. In the Central African Republic, egg laying chickens (at a stocking density of 3,000 chickens/ha) integrated with *O. niloticus* (30,000 fingerlings/ha), during a grow-out period of 189 days in 500 m<sup>2 ponds, have produced an extrapolated yield of 5.5 t of fish/ha/year, plus 2,746 eggs/year.

A.2.Fish-Pig farming integration

If the floor of the pig shed is higher than the pond dike, a manuring ditch can be dug to collect the feces and urine together and the mixture can be flushed directly into the fish ponds. The number of pigs per ha of ponds area varies from 40 to 300. The number of piglets recommended is generally 100 per ha or 1 piglet per 100 m. Piglets are weaned at two months (average weight 12–15 kg) and are ready for fattening. They reach 70–85 kg after 6–7 months. In Central African Republic, in ponds stocked with *T. niloticus* at a rate of 20,000 fingerlings/ha, the combined production can reach 8,000 kg (8 T) of fish and 6,000 to 9,000 kg (6–9t) of pigs (on the hoof) per ha/year.

B. Fish- Cattle/goat farming integration

Cows are reared in pens or sties built on the banks of the fish ponds (and wastes are washed out) or constructed over the ponds on piles or wooden stilts and have a lattice type of floor (allowing wastes to fall directly into the pond). Fish farming is also integrated with cattle and goat rearing, but less so than with such establishments poultry or pigs.

B.1.The constraints are the following

- ✓ The rearing of small-scale farming systems of these animals are mainly free range
- ✓ Their waste products are not as rich in nutrients as the birds and pigs.
- ✓ The free range nature demands a lot of labour to collect the dung over a wide area and put into the pond.
- ✓ Most ruminants are reared extensively and their wastes are bulkier and poorer in nutrients.
- ✓ In intensive rearing systems, stocking densities of 400-500 goats(40-50 head of cattle)per hectare or 10 goats(One head of cattle) per 200m^2 of ponds have been used.

- ✓ The animal house is constructed at higher elevation than the fish pond in such a way that manure can be washed directly into the pond.

C. Fish-crop integration

- ✓ Pond water can also be used to irrigate crops, vegetables and fruits grown near the pond or on the pond dyke.
- ✓ On farm agricultural products like broken cereals, which are considered to be spoilt and of low value can also be utilized as food for fish.
- ✓ Alternatively, nutrients that accumulate in the mud at the bottom of the pond during the series of fish production can be used to grow crops in the pond during a fallow period.
- ✓ The nutrient-loaded mud has been found to produce better gardens.
- ✓ Pond-nutrient rich mud can also be dredged and spread on dykes where plants can be grown.
- ✓ The pond dykes are used for growing crops or grass, which are in turn used to formulate fish feeds or feed the fish directly in the pond.
- ✓ The pond silt acts as fertilizer to improve crop yield on the dykes.
- ✓ In some countries, different types of grass palatable to fish are grown on the dykes and when they grow they are directly cut and fed to the fish.
- ✓ A good example is the feeding of grass to a type of fish called grass carp. Crops mainly grown in integrated farms include: cabbage, soybean, yams, sweet potatoes, pumpkins, maize, wheat, rice and rye grass.

C.1.Fish-Vegetable farming integration

- ✓ Green fodder around the ponds can be used directly to fertilize the ponds.
- ✓ The vegetable material is first composted and fermented before being applied to the pond.
- ✓ Composting is done by covering fodder under shade.
- ✓ The compost is kept moist by watering for a period of one month.
- ✓ During pond fertilization, the compost is placed in a crib at the edge of the pond. Can be dredged during repair and spread in the surrounding gardens as fertilizer to improve productivity.

C.2.Fish-Rice farming integration

- ✓ This is carried out particularly with paddy rice cultivation where the rice field is flooded during most of its growth period.
- ✓ The paddies are then drained when the rice is ready for harvesting.
- ✓ Fish is stocked during the period the rice fields are flooded and harvested when the fields are drained.

Advantages of fish-rice culture

- ✓ Additional food and income from fish

- ✓ Fish controls mollusks and insects which are harmful to man and the rice crop.
- ✓ Continued flooding of paddy and rooting activity of fish help control weeds.
- ✓ Fish stir up soil nutrients making them more available to rice. This increase rice production

Disadvantages of rice-fish culture

- ✓ Rice-fish culture may require more water than rice culture alone
- ✓ Rice yield per unit area is usually reduced because paddy areas used for trenches are not planted with rice.
- ✓ Fish produced within this system are often small in size
- ✓ The total production is lower than what could be produced in a pond of equal size

C.3.Integration with fruits, vegetables and flowers

Fruits, vegetables and flowers can be grown either on the pond dykes or in the gardens surrounding the ponds. Such crops take advantage of the pond water, which is used to irrigate them and can also benefit the nutrients in the mud at the bottom that can be dredged and spread on the gardens. Such vegetables as cabbages or *Amaranthus sp* (Dodo) and fruits like oranges and tomatoes have been grown that way.

D. Fish farming-industry linkages

Industries produce a number of wastes and by-products which are of potential benefit to the fish farming industry.

They include:

- ✓ Blood meal from slaughter-houses, good for improving the supply of protein for fish
- ✓ Chicken offal from broiler farms and slaughter houses
- ✓ Fish trimmings from fish-processing factories, Maize and rice bran from grain mills, Sweepings from cassava and millet flour mills
- ✓ The oil residues from processing of cotton seed, sunflower, sesame seeds
- ✓ Brewery wastes or the beer dregs (local and industrial) have been used for feeding fish with good results for their growth. This can be produced from local brews and/beer factories

- Content/Topic 5: Maintain, monitor fish pond and Harvest fish

In order to achieve a high fish production in the pond, regular maintenance and monitoring is necessary. 1.

1.Daily management includes making sure that one should:

- ✓ Check the water quality (temperature, pH, early morning dissolved oxygen levels)
- ✓ Check the pond for possible water leaks
- ✓ Clean the screen of the water in- and outlet

- ✓ Watch the fish while feeding: Do they eat normally? Are they active? If not, check dissolved oxygen level (if near zero stop feeding and fertilizing and flow water through the pond until fish behave normal again) or look for symptoms which could indicate a disease
- ✓ Watch out for predators and take precautions if necessary
- ✓ Remove aquatic weeds growing in the pond
- ✓ Check Turbidity as the term for the amount of dissolved suspended dirt and other particles in the water which give the water a brown colour. High turbidity of water can decrease fish productivity as it will reduce light radiation into the water and thus oxygen production by the water plants, clog filters and injure fish gills.

A. Fish Harvesting

Good farming practices include regular harvesting of the crop to earn the farmer an income. The frequency of harvests and the quantities and returns realized are key indicators of the economic viability of the enterprise. With good management, as described in the preceding sections, the fish should be ready to harvest within six to nine months after stocking.

A.1.Types of fish harvesting

There are two types of harvest: partial harvest, and complete harvest.

- **Partial harvesting**

A partial harvest is catching only some of the fish in the pond. For example, the farmer may wish to take only the big size fish to sell in the market or to feed his family or for a special occasion. Partial harvest can be done either by seining or by using a cast net.

Complete harvest

- **Complete harvest**

Complete harvesting requires draining of the pond. To speed up the harvesting, seining is carried out while the pond is draining. When the pond is drained completely, fish are confined in the catch pit or in puddles of water and these remaining fish are scooped or collected by hand. A net bag can be held on the outside of the outlet pipe to catch any fish that escape down the pipe, or the inside of the pond can be screened around the outlet pipe to stop fish from escaping.

- **Preparing for the harvest**
- ✓ Make marketing arrangements well in advance of the harvest date.
- ✓ Plan to harvest your fish early in the morning or early in the evening. So that the pond water is still cool while the pond is emptied. This will reduce fish stress while they are being seined or collected.
- ✓ Stop applying fertilizers one to two weeks prior to harvesting.

- ✓ Stop feeding the fish two days before harvesting; So as to allow the fish to empty their guts.
- ✓ Set up all harvesting and transportation equipment well in advance. For example Aeration, inflow of clean water, holding tanks, buckets, seine nets, scoop nets etc
- ✓ Prepare the manpower.
- ✓ Partially drain the pond very early in the morning on the day of harvest.

A.2.Fish Harvest techniques

- **Fish harvesting using nets**

There are different kinds of nets with which can harvest the fish from the pond including Seine net; gill net; lift net; scoop net; cast net.

- **Seine fishing nets**

One of the main pieces of equipment used to catch fish is the seine net. This is the easiest way to catch alevins. If a seine net with mesh of approximately 1 cm is used, the fish that are caught will be at least 5cm in length. Seines made with mosquito netting should be used to collect juveniles. A seine net is the most common type used to harvest fish on fish farms. It is a long net with ropes at each end that is pulled along the pond to collect fish and then drawn into a circle to trap them and, most often, bring them back to shore. A seine net consists of one or more pieces of mounted netting material:

At the top, a head line is equipped with floats. At the bottom, a foot line is equipped with sinkers (or leads). These head and foot lines normally extend beyond the netting to form pulling ropes.

There are several kinds of seine. The two most commonly used designs are: A seine that is the same over its entire length. It consists of a simple rectangular net panel.

A seine made of three parts:

- ✓ One central,
- ✓ loosely mounted bag that collects the fish,
- ✓ Two lateral wings that lead the fish toward the central part.

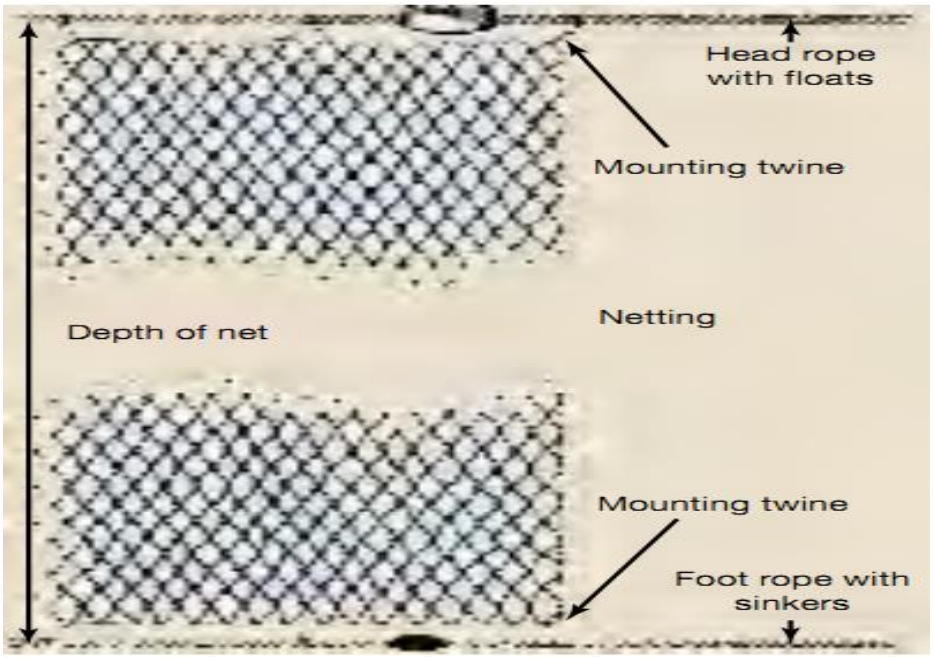


Figure 23: Diagram of a seine net

- **Gill net**

The gill net is one of the most widely used nets in freshwater capture fisheries. It may also be useful on a farm for selective harvesting of larger fish for market.

In overall shape and design, a gill net is very similar to a seine net. The netting twine is thinner and usually made of a synthetic monofilament, such as polyamide monofilament, with a diameter from 0.12 to 0.25 mm, depending on the mesh opening. Mesh size is determined by the size of the fish being harvested. Fish should be able to pass through the extended mesh just beyond their gill covers, but no further. When they feel caught and try to back out of the mesh, their gill covers should be caught by the mesh sides (which is where the name «Gill net» comes from).

Such nets are highly selective. The mesh size is calculated by measuring the body perimeter, or girth, of a few fish of the size that will be harvested. The stretched mesh size of the gill net should be about a quarter smaller than the fish girth.

Avoid gill nets with a stretched mesh size of less of 4 cm, so that you don't catch fish that are too small. It is important to check and remove fish from a gill net every few hours at the most to ensure that harvested fish will remain alive and not suffer injuries.

- **Cast nets**

The cast net is another type of non-destructive fishing gear that fishermen often use for capturing fish. It is a good tool for capturing large fish without damaging them. A cast net is made of a flat circular piece of small-mesh netting, heavily weighted along its periphery with sinkers. Usually a series of strings runs from the outer edge through a central ring to join into a single pulling rope. A cast net is not very easy to make,

but can be bought from a specialized store. Handling of a cast net requires skills. When it is thrown, it should be open and horizontal to the surface of the water. The net sinks rapidly to the bottom, and is closed with a pull on the central rope that traps the fish inside the net. A cast net can be used either from the banks, in the water, or from a boat.

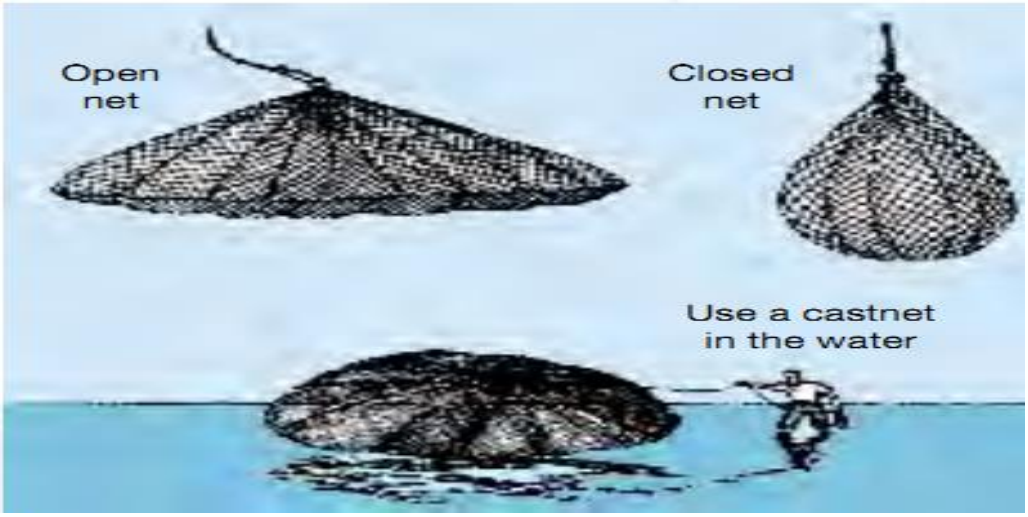


Figure 24: Cast net

- **Dip or hand nets**

Dip nets are commonly used on fish farms to handle and transfer small quantities of fish. Farmers can buy completed nets, assemble them from ready-made parts, or make them themselves.

A dip net has three basic parts:

A bag, made of netting material suitable in size and mesh type for the size and quantity of fish to be handled

A frame, from which the bag hangs, generally made from either strong galvanized wire or an iron bar (usually circular, triangular or «D» shaped, with fixing attachments for the handle);

A metal or wooden handle, 0.20 to 1.50 m long, depending on what the dip net will be used for. The size and shape of dip nets vary greatly. It is important to keep the following guidelines in mind. Live fish should be handled with dip nets that have relatively shallow bags. They should not reach more than 25 to 35 cm deep. Select a size that is appropriate for the size of fish you are handling.

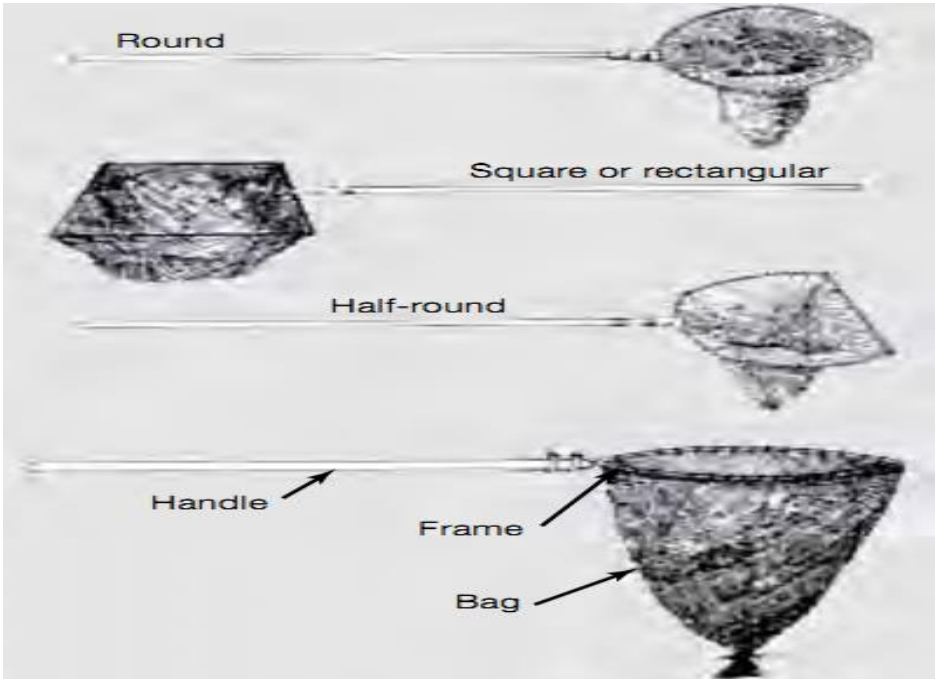


Figure 25: Different types of dip nets

- **Fish Harvesting by Using Drainage**

Closing of the inlet and opening of outlet will allow drainage of the pond and easy harvest of fish stocked in the pond. It is this control that defines fish farming. The fish rearing unit can be drained partially or totally drained at the time of harvesting.

General considerations

- ✓ If the water is muddy, it may be treated with the addition of gypsum at the rate of 20 T/ha which will clear the water in a week.
- ✓ If the fish come to the surface, particularly during cloudy days owing to depletion of oxygen, a portion of the water may be pumped out and fresh water may be allowed in.
- ✓ If fish mortalities are due to the deficiency of oxygen, 10-20 kg of superphosphate/ha may be broadcast during mid-morning hours, so that the photosynthetic activity of the phytoplankton may be enhanced to liberate the required oxygen to avert further fish mortalities.

- **Fish harvesting by using traps**

- ✓ Many different kinds of traps can be used when fishing in lakes and rivers in the effort to capture brood stock or associated species such as catfish.
- ✓ Certain kinds of traps may be useful for Simple and regular harvest of fish for food that does not disturb the rest of the pond stock.
- ✓ These traps are usually made with wood, plastic pipe, bamboo or wireframes, and have surfaces made of netting, bamboo slats or wire mesh.

- **There are two main types**:

Pot traps

Pot trap are usually baited and have a funnel-shaped entrance through which fish can enter but cannot escape; and

Bag or chamber traps

Bag trap usually have a guide net that leads the fish into a chamber and a V-shaped entrance that keeps them from escaping.

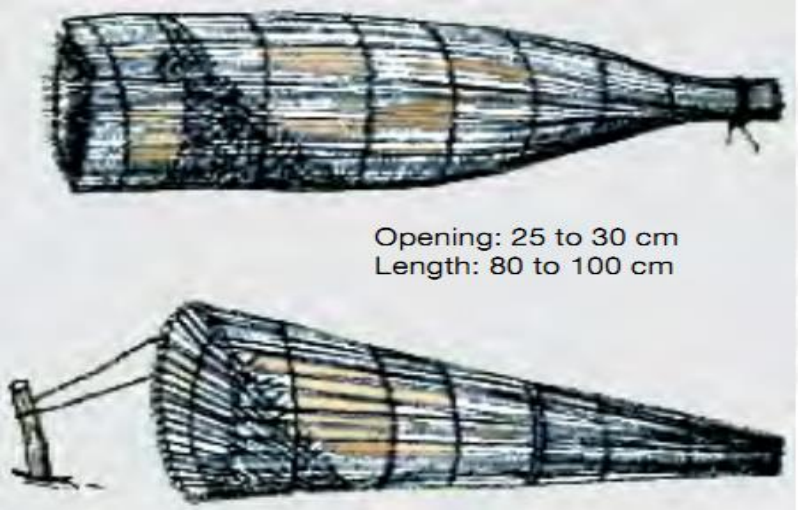


Figure 26: Different types of local traps

- Content/Topic 6: Rearing data collection and interpretation

A fish farm is a business; therefore, all activities on the farm should be recorded. Proper record keeping is a valuable management tool. It is the means to measure the cash input and cash output, in order to evaluate and improve the farm performance and plan for future operations.

The records will assist in showing the farmer how much money can be made from the business (income), and how much money can be saved and spent on the running of business for the next pond cycle.

The records that should be kept include both farm activities such as feeding, reproduction and harvesting

A. Feeding record

Feeds are the most expensive aquaculture inputs due to high protein requirements of the fish; it is therefore, of great importance to keep accurate record of daily feed intake as shown below:

Table 5: Feeding record

Pond number……..Species……				
Date	No of fish stocked	Stocking date	Total weight Of fish	Weight of feed in kg

				AM	PM	Cost of feed

B. Reproduction record

Reproduction record this reproduction includes inducing spawning, hatching, and larval rearing and feeding records as shown below:

B.1.Spawning, incubation and hatching record

Table 6: Spawning and incubation record

Breeding series	Induction brood stock		No of brood female	No of male used	Stripping		fertilization	
	Date	time			Date	Time	Date	Time

Hatching records

Table 7: Hatching record

First hatching		Completion of hatching		First day of feeding	Types of first feeds	Date of first formulated diet
Date	Time	Date	Time			

C. Harvesting record:

Table 8: Harvesting record

Pond number……pond size……species harvested……..				
Date	Number of fish stocked	Number harvested	Average weight (kg)	Total weight(kg)

LO 4.3 – Pre-treat harvested fish

- Content/Topic 1: Post harvest preparation

A. Catching and cleaning fish

Catching and preparing fresh fish

- As fish spoils very quickly, measures must already be taken on board the fishing boat to limit spoilage. First of all, the fish must immediately be kept out of the salt water so that the fish does not get contaminated by bacteria in the salt water(**cleaning**)
- Apart from preventing contamination, one should also prevent outgrowth of bacteria which are already present. The best way is to remove the intestines (**evisceration**) and gills of the fish on board the fishing boat.
- After that the fish must be washed with clean water to rinse off any blood or other remains. It is recommended to transport the fish on ice to shore. However, cleaning and transporting the fish on ice is often difficult and expensive to realize. All that can be done then is to transport the fish as quickly and carefully as possible to the shore. To prevent the bacteria in the intestines, liver, gills and on the skin of the fish from increasing, the fish must be kept in a clean boat and in the shade.
- **Cleaning fish**: To clean fish, first of all one needs good and clean tools. Personal hygiene is also important. It is important that the fish is not cleaned on the ground but on a clean table or bench.

The table should be at working height and can be made of wood, metal or concrete. The surface of the table must be smooth and easy to clean. To salt, dry and smoke fish, it is important that the surface area of the fish be increased.

Then the salt and smoke particles can penetrate easily into the fish and moisture can work its way out.

B. Gutting and scaling

- ✓ Place the fish on a clean board and hold it by its head.
- ✓ Scrape the scales off starting at the tail and working towards the head.
- ✓ Try not to damage the skin of the fish while doing so.
- ✓ Wash the fish in clean (drinking) water and remove all loose scales.
- ✓ Lay the fish on its side on a clean board and cut into the fish along its gills with a sharp knife.
- ✓ Do the same on the other side but do not cut the head off.
- ✓ Cut the gills free by cutting the ends free from the head and body with the point of the knife.
- ✓ Slit the abdominal wall open from the anal opening towards the head of the fish.
- ✓ Cut deep enough but try not to damage the intestines of the fish.
- ✓ When the fish has been opened up, the gills and intestines can be removed by placing one's fingers under the gills and pulling everything out.
- ✓ Scrape any remaining blood out with the knife.
- ✓ Clean the abdominal wall with clean (drinking) water.

C. Splitting

C.1.Small and medium-sized fish

- ✓ Place the fish on a clean board with its back facing you and its head to the right if you are right-handed.
- ✓ Slit the fish open down the middle from the head to the tail, along the middle fish bone, but do not cut into the underbelly.
- ✓ Open the fish and remove the intestines and gills.
- ✓ Wash the fish thoroughly with clean (drinking) water.

C.2.Splitting of large fish

- ✓ Extra cuts are made in the flesh of large fish to increase the surface area and to decrease the thickness of the fish.
- ✓ Place the fish on a clean board, with the abdominal side facing you and the head to the right if you are right-handed.
- ✓ Make a cut in the fish from the gill arch to the tail so that a strip of fish-flesh is left.
- ✓ Turn the fish over and open it up.
- ✓ The strip of flesh must remain attached at the back.
- ✓ Place the fish with its head to the right and the abdominal side facing you.
- ✓ Split the head open and cut towards the tail so that a second strip of flesh is formed.
- ✓ In doing so, the abdomen is also cut open.
- ✓ Open the fish and remove its intestines and gills.
- ✓ Then wash with clean (drinking) water.

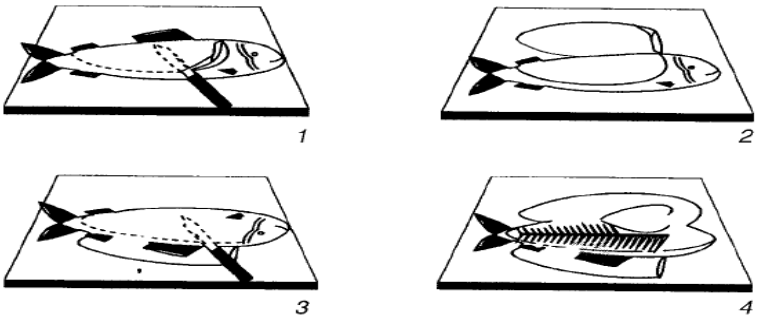


Figure 27: Fish filleting

C.3.Small fish

- ✓ One can use a fish which has not been cleaned for this.
- ✓ Place the fish on a clean board with its back facing you.
- ✓ Place the head on the left if you are right-handed.
- ✓ Cut along the contours of the gill arches until you hit the backbone.
- ✓ With one slice, cut the fillet loose from the backbone from the head to the tail.
- ✓ In doing so, the abdomen is cut open.
- ✓ When the fillet is loose, you can see the intestines and other organs.
- ✓ Turn the fish over so its abdominal side faces you.
- ✓ Repeat steps 1, 2 and 3.
- ✓ If necessary, cut the fins from the fillets.

- ✓ Then wash the fillets with clean (drinking) water.

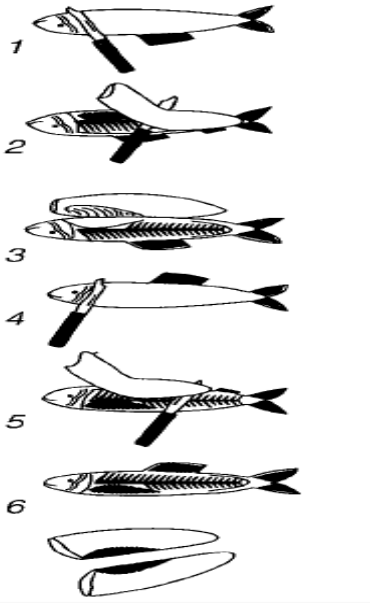
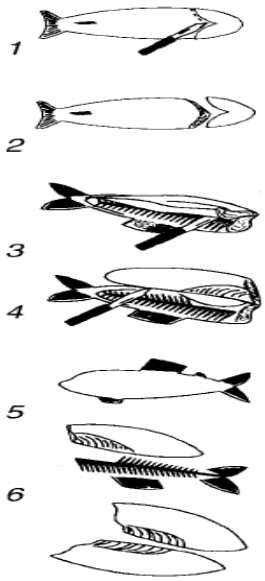


Figure 28: Filleting of large fish



C.4. Large fish

- ✓ Place the fish on a clean board with the stomach facing up.
- ✓ For right-handed people the head must be on the right.
- ✓ Cut along the contours of the gill arches.
- ✓ Remove the head and intestines.
- ✓ Place the fish on its side.
- ✓ For the first fillet, start at the head end and cut the fish in the direction of the tail to halfway along the backbone.
- ✓ Cut as close to the backbone as possible.
- ✓ Also cut the other side of the fillet loose.
- ✓ Turn the fish so that its tail is to the right.

- ✓ Remove the other fillet from the backbone.
- ✓ If necessary, remove the fins from the fish.
- ✓ Wash the fillets with clean (drinking) water.

- Content/Topic 2: Fish preservation techniques

1.The choice of a preservation method depends on:

- The product, the desired properties of the product to be stored,
- The availability of energy sources (wood, gasoline, oil, electricity, and sun),
- The storage facilities, possible packaging materials and the costs involved for each method.

It is sometimes necessary to combine methods, such as salting and drying or adding acid and then sterilizing. It is also desirable to conform to local customs if the products are to be acceptable to the local population.

2. There are several methods of fish preservation including:

- Salting,
- Drying,
- Smoking,
- Cooling and freezing and are summarized below:

A. Salting

A.1.procedure

- ✓ Storage life is prolonged.
- ✓ Salt absorbs much of the water in the food and makes it difficult for micro-organisms to survive.
- ✓ For salting, it is important that the fish has been prepared in such a way that the salt added can quickly draw into the flesh and the moisture can leave the fish.
- ✓ Fish are divided in half or even in quarters depending on their size.
- ✓ Fish smaller than 10 cm usually only have their intestines removed.
- ✓ Fish of ± 15 cm are split open so that the surface area of the fish is increased, salt can penetrate better, and the flesh of the fish therefore becomes thinner.
- ✓ Large cuts can be made in fish 25 cm or longer, or these can be split a number of times.
- ✓ To learn how to salt fish, for example the amount of salt needed and the effect of those quantities on the firmness and the taste of the fish, it is recommended at first to use small amounts of different kinds of fish that are easily available.
- ✓ It is easier to start with non-fatty kinds of fish.

- ✓ Lean fish is recognizable by its white or very pale flesh.
- ✓ More fatty fish usually have a darker colour.

A.2.During the salting of fish, attention must be paid to the following:

- ✓ Use the cleanest salt available.
- ✓ Use enough salt. Note that salting products is not the same as using a lot of salt.
- ✓ Large amounts of salt give fish and meat a very salty taste.
- ✓ At the same time many of the nutrients are lost if too much salt is used.
- ✓ The water which is to be used must not be contaminated; it must be clean and clear (drinking water quality).
- ✓ The most effective way of preserving fish and meat is to combine salting with smoking or drying.

A.3.How salting is done:

- ✓ Put a thick layer of salt on the bottom of the barrel.
- ✓ Put one layer of fish on the salt with the skin facing up.
- ✓ Cover the fish with a layer of salt and make sure that no parts are left uncovered.
- ✓ Use more salt at deep cuts or thicker flesh.
- ✓ Alternate one layer of salt, one layer of fish, etc.
- ✓ Make sure the fish do not overlap. Finish with a layer of fish with the skin facing up.
- ✓ Cover the final layer of fish with a thick layer of salt.
- ✓ Cover the barrel with the lid and distribute the weights evenly on top of it.
- ✓ by adding salt to fish, moisture is drawn out of the fish.
- ✓ This moisture, with the salt dissolved in it, is called brine.
- ✓ Because more water is drawn out of the fish, the brine in this wet method becomes diluted.
- ✓ The brine must be topped up with salt to keep it saturated.
- ✓ This can be done by hanging a jute bag filled with fine salt in the brine.
- ✓ Keep the brine saturated. This can be done by hanging a jute bag filled with fine salt in the brine
- ✓ Using unsaturated brine will lead to spoilage.
- ✓ If, after several hours, the level of the created brine does not reach the lid, a saturated salt solution must be added.
- ✓ The salt solution is made of at least 360 grams of salt dissolved in each litre of water.
- ✓ Heat the solution in a pan and let it boil for 10 minutes.
- ✓ Let the brine cool down until it is warm to the touch.
- ✓ Then add the brine to the barrel with fish until it reaches the lid.
- ✓ Keep the barrel in as cool a place as possible

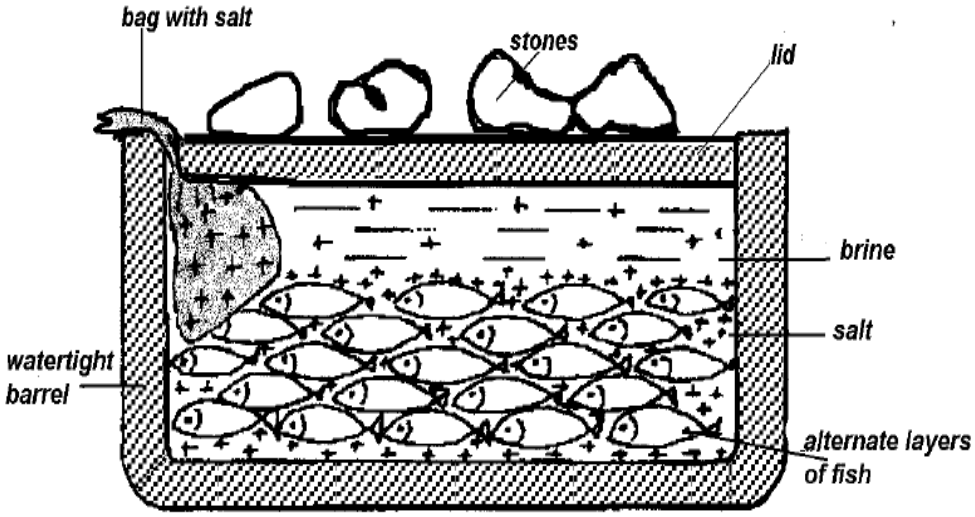


Figure 29: Fish salting

A.4. Pickle curing

- ✓ After being salted, the fish must look clear and see-through.
- ✓ The fish must feel firm and have a whitish salt layer all over them.
- ✓ A fishy smell and the smell of brine must dominate.
- ✓ Check the container regularly.
- ✓ If foam appears on top of the brine (a result of fermentation), replace the old brine with a fresh brine solution.

A.5. Brining

- ✓ With this method, fish is soaked in a solution of water and salt (brine). Brining is not used as such as a preservation method but as preparation for smoking or drying.
- ✓ The use of a light salt solution ensures a decrease in bacterial growth on the surface of the fish during the smoking or drying process.
- ✓ It also protects the fish against insects and other vermin; however, the protection provided is not complete.

B. Drying fish

Whole fish, fish fillets can also be dried on drying racks made of chicken wire or bamboo poles. The disadvantage of this method is that, due to the contact between the fish and the poles or wire, there is a chance the product will remain moist in places and thus cannot dry completely.

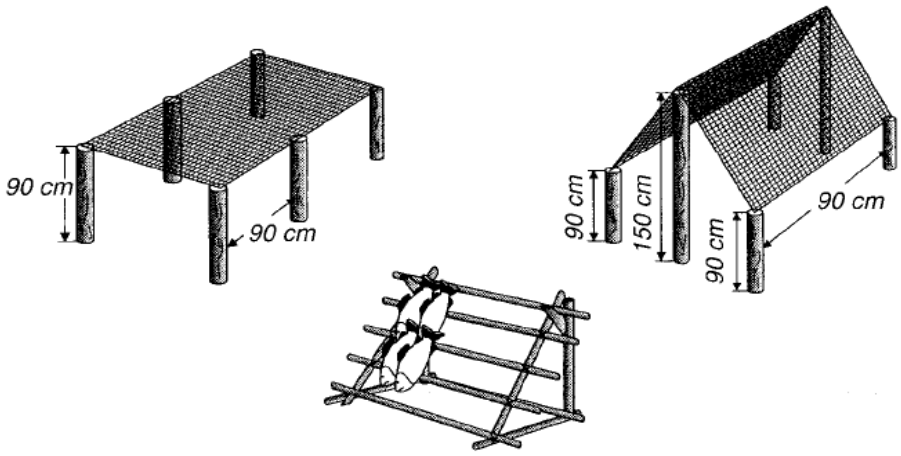


Figure 30: Drying fish

B.1.The drying process

- ✓ Drying must take place carefully and uniformly.
- ✓ The best results are achieved in dry weather with a lot of wind.
- ✓ Take care that the fish does not get so hot the fat starts to melt or that a crust is formed on the surface.
- ✓ The inside of the fish would then stay moist which would make it spoil quickly.
- ✓ Therefore, do not put the fish to be dried directly in the sun at the start of the drying process.
- ✓ In the early morning or the late afternoon sun, the product to be dried will stay relatively cool, but in the middle of the day it must be protected against overheating by temporarily putting it in the shade.
- ✓ If drying racks are used, the pieces of fish must be turned every two hours so they dry uniformly.
- ✓ The product to be dried must be protected as much as possible against vermin and insects.
- ✓ Insects are carriers of various bacteria which can cause the product to spoil.
- ✓ Bluebottle or carrion flies lay their eggs on the still damp product and their larvae eat the flesh. Beetles of the species Dermestes lay their eggs especially in the already dried product.
- ✓ Try to prevent such insects from nestling in or near the material to be dried.
- ✓ To do so, remove all animal waste from the immediate vicinity.
- ✓ This is a highly suitable breeding place for these kinds of insects.
- ✓ Using a good salting technique helps to keep the insects at a distance during drying.
- ✓ Also use mosquito netting to keep insects, and especially the bluebottle/carrion flies, away.
- ✓ Do not let the netting touch the material to be dried.
- ✓ Put the drying rack at least one meter above the ground so that other vermin do not get a chance to get to the product.
- ✓ Put the legs of the rack in a pan of water to which a little oil has been added.

- ✓ The fish must be protected against dusty wind, rain and dew.
- ✓ The products can be covered with banana or palm leaves or plastic.
- ✓ They can of course also be put under an awning or in a shed.
- ✓ However, put the products to be dried out in the sun again as soon as possible to let them dry further.

B.2.Storage and use of dried fish

- ✓ How long fish must dry depends on the **type** of fish, its **size** and the **weather**.
- ✓ The final moisture content must be less than 25% to prevent microbial spoilage. Weighing the fish before and after the drying process can tell you whether the fish is dry enough.
- ✓ If during the drying process the weight of the fish does not decrease further, it is sufficiently dry. In general, naturally dried fish needs about 3-10 days to dry.
- ✓ After drying, the dried fish is difficult to bend.
- ✓ Some of the dried fish products are very crumbly and breakable and must be handled with care after being dried.
- ✓ In dry climates it is possible to store dried fish in sealable, sturdy boxes or wooden crates in which ventilation holes have been made. The holes must be covered with mosquito netting to keep out insects and vermin.
- ✓ In humid conditions dried fish can take up moisture from the air and must be packed airtight. An additional advantage of airtight packaging is a delay in the onset of rancidity in fatty fish. Strong plastic bags can be used which are then closed properly. These provide protection against insects and moisture. However, the bags should not be placed in the direct sun or in warm places.
- ✓ The product can then start sweating; there is, after all, some moisture left. This moisture can cause moulds to grow on the fish. When such moisture is seen, the fish should be re-dried in the sun for several hours and re-packed.
- ✓ Store the packed, dried fish in a cool, dry, well-ventilated and dark place.
- ✓ Before unsalted or salted dried fish can be eaten, it must first be soaked in clean, cold water for 48 hours.
- ✓ However, preserved fish, whether salted, dried and/or smoked, must eventually always be heated to 100 °C before being eaten.

C. Smoking

The fish can also be preserved by smoking. The preserving effect of the smoke is a result of drying (withdrawal of moisture) of the product during the smoking. The smoke particles, absorbed by the flesh,

also have a preserving effect which, however, is less than the drying effect. The smoke particles, after being absorbed by the product, inhibit bacterial growth on the surface of the product. The smoke particles also have a positive effect on the taste and colour of the product. The heat of the fire dries the fish during the smoking process and if the temperature gets high enough, the flesh is cooked. This means that bacterial spoilage and spoilage due to enzyme activity is prevented. Drying and cooking of the flesh when being smoked play an important role in the preservation. If a product is well dried during smoking, then it can be stored for a long time. The figure below shows how smoking is done.

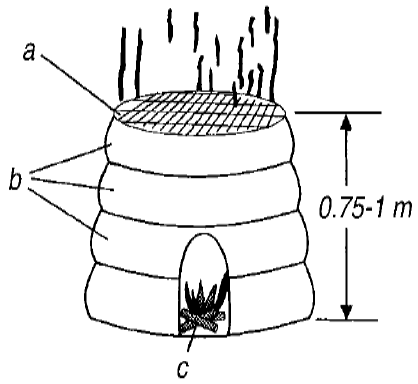


Figure 31: Fish smoking

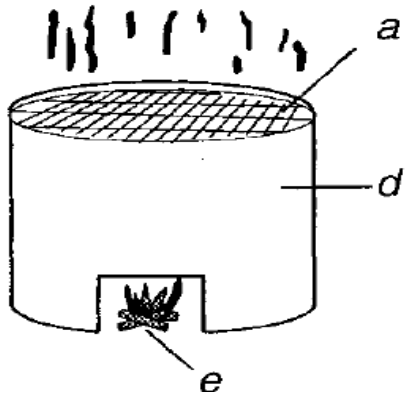


Figure 32: Improved grill

a:wooden grill on which fish is laid

b:dried mud layers

c:smouldeling fire ;opening in the mud layers

d: Oil drum

e: Fire

The smoked and dried final product should be clearly brown, nice and dry and have a hard structure. If the final product is well dried, it can be kept for several months. The final product can be eaten dry or cooked well in clean (drinking) water.

D. Cooling and freezing of Fish

Because of the low temperatures, all (bio) chemical, physical and micro- biological processes are slowed down so decaying does not occur. To increase the storage life of the product, it is important to lower the temperature very quickly so as to preserve its quality. If the freezing goes too slowly, large ice crystals are formed which affect the structure of the product.

Cooling of fish is often done by keeping it on ice. This requires ice-making machines. Very expensive and advanced freezing equipment is needed for the freezing of fresh fish.

Whole fish, with the intestines and gills removed, and fish fillets are often cooled (at 0°C) by putting ice on them. Alternating layers of fish and ice are put in a box. Be sure to use at least as much ice as fish. One should always end with a layer of ice. When the ice has melted, new ice must be added to keep the fish at 0 °C. Especially with fatty fish it is important to cool quickly so that oxidation of the fat is slowed down.

Fish can also be stored in cooling cells. The temperature there is just above freezing point, so ice lying on the fish melts and the fish stay fresh. This way fish will not freeze. The boxes in which the product are kept must not be kept on the ground, against a wall or against each other, but in clusters on pallets and slightly away from walls so that air can circulate freely.

If one wishes to store fish for more than 2 or 3 weeks, it must be frozen.

For the freezing of fish in freezing cells, a temperature of -30°C is recommended. If good quality fish is frozen at -30 °C quickly after being caught, then it can be stored for a very long time.

Learning Unit 5 –Control fish diseases and predators

LO 5.1 – Control fish predators

- Content/Topic 1: Common fish predators and their control

Farmed fish can be preyed upon by fish-eating birds, frogs, tadpoles, snakes, otters, monitor lizards and insects such as backswimmers. Of all these, tadpoles can be nuisance in earthen ponds. These predators may be controlled by fencing all the nursery ponds to deny frogs entry into the ponds where they lay eggs. Liming may also be used to kill off any predators that may be in the pond.

The common predators of fish include:

A. Amphibians (Frogs)

Frogs easily find their way into fish ponds and can be a big nuisance in fish farming. Adult frogs eat fish eggs and larvae while newly-hatched ones compete with fish fry for food. Some frog species feed on fish fry thus affecting the production potential of the fry production.

A.1.Control of amphibians

- ✓ Use of baited traps especially for xenopus *sp.*
- ✓ Destruction of amphibian eggs. This is done from the banks of the pond using a scoop nets
- ✓ Use a polyethylene or iron sheets erected around the pond to keep away frogs which are known to be predators and competitors of fish.

B. Reptiles

Harmful reptiles are those which swim easily and live most of their life in water. These eat fish fry and even some good sized fish. The monitor lizard is one of the most frequent and harmful fish predators.

B.1.Control of Reptiles

Monitor lizards are controlled by keeping grass around the ponds as low as possible and by setting traps to catch them. Farmer innovations in east Africa have shown that tobacco scares away snakes from fish farms.

C. Voracious fish

Voracious fish like Nile perch feed more or less exclusively on fish. They should not be stocked with other fish unless they are intended to check populations of the fish with which they are cultured.

D. Crayfish

Crayfish can also cause considerable damage to fry and brood stock once they inhabit a fry production facility. Crayfish grasp and cut fry into pieces.

Crayfish are difficult to eliminate from a fish farm once they are introduced. They burrow in the pond banks where they hide when the pond is drained and appear when it is refilled.

D.1.Prevention of damage by crayfish

The pond should be screened effectively at the water inlet using a powerful screening net material. Prevention of crayfish spread is by avoiding sharing nets and tools with farms that have crayfish.

E. Harmful Invertebrates

The most harmful aquatic insects found in culture facilities include: water beetles, water bugs, dragon flies and the back swimmers.

E.1.Prevention of insect predators

- ✓ Do not place the nursing pond under water for more than 15days before stocking.
- ✓ Clean swamps and grassy ditches in the neighbourhoods of the fish farm.

F. Harmful birds

There are number of fish-eating water birds which cause serious damage to forms. These include the kingfisher (*Alcedoathis*), marabou storks, harmer cops, grey herons (*Ardeacinerea*), and cormorants among others. The marabou stork and the grey heron are common in ponds with shallow waters.

These two types of bird cause considerable damage to fish in ponds. They can swallow whole fish measuring 15 to 20cm and can cause considerable injuries to large adult fish, especially catfish. There is also a certain duck-like bird that is extremely dangerous to fish fry. It swims on water as it picks the fry from pond.

F.1.Control of birds of prey

Birds are controlled by criss-crossing strings on top of the ponds to prevent the predators from dividing into the ponds.

- ✓ Strings or wires or nets are often used to partially cover aquaculture systems.
- ✓ Pond water should not be allowed to fall to levels where birds such as the marabou stork can see the pond bottom. These birds will never walk into the pond if pond water is high. When the water level falls due to leakage or dry season, they congregate in large numbers and walk into the pond where they kill the fish and injure others. They can cause great loss within a very short time.

G. Harmful mammals

G.1.Otters (*Lutra lutra*)

Otters principally live on fish but can supplement their food with other organisms. These animals are wasteful and can be best described as malicious. They attack relatively large fish and eat off a part and leave the rest to rot.

They destroy more than they can eat. They are nocturnal animals roaming and hunting on clear nights. They swim swiftly and can dive and stay under water for a relatively long time.

Otters usually move about covering long distances between ponds or follow water courses but return from time to time to the same point. They can easily be traced because of their webbed foot prints. Their excreta can easily be recognized as it is mixed with bones and scales of fish.

Control of otters

The best means of combating otters is by the use of traps. This is because otters generally follow the same route. Solid toothed traps with 18cm openings should be used

LO 5.2 – Identify fish diseases

- Content/Topic 1: Fish specific diseases

1. Fish specific diseases

- ✓ Bacterial diseases
- ✓ Viral diseases
- ✓ Fungal diseases
- ✓ Parasitic diseases

2. Common disease symptoms in Fish Behaviour

2.1. Symptoms

- Feeding decreases or stops
- Swimming: weak, lazy, erratic
- Floating in water head up
- Rubbing against hard object
- Flashing/twisting, darting repeatedly
- Crowding/gathering in shallow water or at water inflow
- Individual fish isolated from the main group of fish

2.2. Physical signs

- Gaping mouth
- Body: open sores, lesions, bloody areas, loss of scales, bloated belly, abnormal coloration
- Gills: pale, eroded, swollen, bloody or brownish
- Fins: folded, eroded,
- Eyes: cloudy or distended
- Presence of disease organisms on skin, gills, fins

There are three major groups of living organisms that may be responsible for fish diseases:

- Bacteria
- Viruses

- Parasites

A. Bacterial diseases

The common bacterial diseases are fin-and- tail rot, dropsy and eye disease

A.1. Fin-and- tail rots

Fin-and- tail rot caused by ***Pseudomonas sp.***is the most common contagious disease.

- **Symptoms**

Initially, a faint white line is seen on the margin of the infected fin, which eventually causes disintegration and putrefaction of the entire fin.

- **Treatment**

Infected fry and fingerlings should be given a group treatment in 1: 20000 copper sulphate solutions. Larger fish should be treated by dipping them in a 1: 20000 copper sulphate solution for 1-2 minutes.

A.2.Dropsy

Dropsy is caused by ***Aeromonas sp.*** At times it takes serious epidermic form.

- **Symptoms**

Infected fishes show scale protrusion, inflammation of the belly, bulging eyes and anaemia. They suffer from accumulation of water in the body cavity and scale pocket. Scales eventually become loose and fall.

- **Treatment**

Infected fish should be given dip treatment in 1-5 ppm potassium permanganate for 1-2 minutes. The pond should be disinfected with 1ppm potassium permanganate solution.

A.3.Eye disease

Eye disease is caused by ***Aeromonas liquefascians***, which attacks the optic nerve and the brain.

- **Treatment**

At the early of infection fishes should be given hourly bath in 5-10 mg/liter choloromycetin solution for 3-4 days. The remaining fish of the pond should be given a prophylactic treatment of bath with 1mg/liter of potassium permanganate solution.

B. Fungal Diseases

Most fungal infections are caused by water molds of the family ***Saprolegniaceae***, so fungal diseases in catfish are commonly called *saprolegniasis.*

B.1.Saprolegniasis

- **Symptoms**

Initially, it gives rise to the ulceration of skin and eventually leads to haemorrhage. The mold appears as tufts of minute white hair like outgrowths on the affected part of the body.

- **Treatment**

Infected fish should be dipped in 3% common salt solution or 1: 3000 copper sulphatesolutions once daily for 3-4 days. They should also be dipped in 1: 10000 malachite green solutions for 3 seconds.

B.2.Gill rot

Gill rot in another common fungal disease caused by a filamentous fungus Branchiomysis.

- **Symptoms**

The gill filaments of the infected fish become whitish and eventually drop off. Such fish can be seen gasping for air at the surface before they die.

- **Treatment**

The Infected fishes should be given bath for 5-10 minutes in 3-5% common salt solution or in 5ppm potassium permanganate solution.

C. Protozoan diseases

C.1.Ichthyophthiriasis

Ichthyophthiriasis or the white spot disease is caused by ***Ichthyophthirius sp.***

- **Symptoms**

The Infected fish show small whitish cysts of about 1mm diameter on the body gills and fins.

- **Treatment**

The fishes should be dipped in 2-3% common salt solution for 2-3 minutes for 6-7 days. Quick lime 300-500 kg/ha can be applied to the pond in 2 to 3 instalments.

C.2.Trichodinosis

Trichodinosis is caused by ***Trichodina sp.***

- **Symptoms**

The Infected fishes show symptoms of irritation and respiratory trouble since skins and gills affected. They come to the surface of water and rub their body on the margin of the pond. The gills and the skin secrete excessive amount of slime, which results in bluish-white coating on the skin.

- **Treatment**

Dip treatment with 2-3% common salt for 5 to 10 minutes should be done for 3-4 days. Also the infected fishes should be treated by dipping them in 1:1000 acetic acid.

C.3.Myxoporidiasis

Myxoporidiasis is caused by different ***myxosporidians.***

- **Symptoms**

It attacks different parts of the body and internal organs. They mostly infect the gills. Their cysts appear as small white or dark- red spots. When the infection is severe white patches on heavily slimed gills become apparent. The fishes come to the surface and show sign of weakness, emaciation, falling of the scales and restlessness. Cysts are highly resistant to any chemical

- **Treatment**

The infected fishes are normally killed and others are treated by common salt solution of 2-3% for a few minutes. The pond water is changed.

C.4.Whirling disease

Whirling disease is caused by the *Myxosporean myxobolucerebralis* infections in the spine can cause the fish's tail to turn black and the spine to curve. Infections in the head cartilage create head and jaw deformities, while infections in the auditory capsule cause the fish to become disoriented and chase their tails in a whirling motion. Heavy infections can kill fish before clinical signs.

If earthen raceways are used, they can be disinfected between production cycles with 380 grams of calcium oxide, also called burnt lime or quick lime) per square meter of pond bottom.

D. Parasites

Worm diseases are also common in fishes. The parasites *Gyrodactylus* sp. and *Dactylogyrus* attack the skin and gills of the fish and feed on blood. The infected fishes show fading of their colour and excessive mucus on their skin.

The most common crustacean parasite, the carp lice (Argulus) attach themselves to the fish by means of suckers and hooks. The infected fish becomes weak and emaciated and loses scales. In such cases pond treatment with Gammexane at a concentration of 0.2ppm should be repeated at weekly intervals twice or thrice.

E. Nutritional diseases

- Deficiency of vitamin B1 (Thiamine) results in atrophy of muscles.
- Vitamin B2 deficiency leads to opaque eyes and also the growth is affected.
- Deficiency of Biotin and Pantothenic acid result in formation of blue coloured mucous known as blue slim disease
- When Tilapia is fed on cotton seed oil cake or groundnut oil cake, deformation of body and fin results.
- Anemia due to nutritional deficiency in trout can be found out by paleness of gills, liver and kidney. When common carp are fed on large amounts of maize or cotton oil cake, rickets develop.
- Muscle and liver lesions in fish are common when their food lacks vitamin E.
- Tumours, particularly thyroid tumours may develop in fish when the food source lacks potassium iodide. A mixture containing one part of iodine and 100 parts of potassium iodide can be added in the food in the ratio of 1: 2500 to avoid the development of tumours in fish.

LO 5.3 – Control of fish diseases

- Content/Topic 1: Hygiene and biosecurity measures

A. Hygiene and biosecurity measures:

A.1. Hygiene

The prevention of fish diseases is essential for the betterment of the fisheries industry, the improvement of farming production, and the increase in fish resources. Because of the complexity of their environment, fish are susceptible to viral, bacterial, fungal, and parasitic infections. These infections will adversely affect growth and development and a serious infection can be fatal. An outbreak of disease jeopardizes regular aquaculture and threatens fish yields. Therefore, controlling disease is one of the most vital tasks in fish culture.

The concept that "*Prevention is better than treatment*" is fundamental to the maintenance of a healthy stock of fish. Because fish are schooling animals, they are hard to observe individually, making the diagnosis and treatment of disease difficult. In addition, some fish diseases are still essentially incurable. Therefore, preventive measures are essential to the control of disease.

A.2.Biosecurity measures

Biosecurity encompasses all measures designed to prevent diseases from occurring and from spreading by isolating, as much as possible, animal farm populations from external contamination. Recurring or prolonged contact with external environments (water, sediment, wildlife) favours the development of new diseases. For this reason, non-recirculate aquaculture systems are more difficult to isolate than closed water circuits.

- **The first level of biosafety relates to the choice of farm location.**

Once the farm facilities have been installed, it is very difficult to change the quality of water inlet. Thus, it is absolutely necessary to have prior knowledge of the farming and industrial activities - livestock as well as crop production – that are conducted upstream of the farm, especially if the water used originates from a stream. Depending on the results of these investigations, the treatment system for incoming water must be adjusted accordingly.

What are the main biosecurity measures allowing for satisfactory growth performance in fish farming?

A.3. On a daily basis, it is necessary to pay attention to the risk factors likely to occur in the various phases of rearing, as follows:

- **The quality of inputs**: whether they are animals (eggs, larvae, juveniles...) or supplies (food, veterinary products...), it is essential to check the quality of all resources that are used in the farm.

- **The quality of incoming water**: this is a more or less controllable variable depending on the rearing system that is applied. After all aspects of the pre-installation phase have been checked, the water must then be sampled periodically. This is a key parameter that needs to be monitored and assessed on an on-going basis.
- **The disinfection of vehicles accessing the farm:** it is common for drivers of vehicles entering a farm to circulate in between several fish farms as they are likely to be veterinarians, feed manufacturers, fish transporter, etc. To this end, wheel dips can be used for better desinfection of cars.
- **The disinfection of equipment used in handling fish**: precautionary measures related to pathogens must be applied to all production units - ponds, cages, ponds or aquarium - within each farm. Therefore, the transfers of equipment from pond to pond must be spaced out as much as possible, especially when it comes to the transfers of nets, which are the most likely tools to be directly in contact with animals.
- **Employee hygiene within the farm**: farm workers must regularly wash their hands; this rule especially applies to those who manipulate animals through sorting, vaccination, feeding... **Hydro** alcoholic solutions have proved efficient and easy to handle to this end. In addition, all employees must have their shoes thoroughly decontaminated. In this respect, placing footbaths ad brushes at the entrance of each livestock compartment can help limit the spread of pathogens. Keeping a regularly updated register of visits also constitutes an important component of the protection process.
- **The manipulation of dead and/or moribund animals**: since dead animals are particularly likely to be contagious, their carcasses should be handled with care so the pathogens they contain will not spread. It is also of the utmost importance to isolate and destroy these carcasses soon after death has occurred.
- **The reduction of the stress level in animals**: limiting animals' stress can favour improved performance. Furthermore, stress has physiological repercussions leading to the spread of diseases in livestock. These guidelines constitute a first line of sanitary measures in aquaculture. However, these are far from being exhaustive and can be tailored to the needs of each farm depending on its characteristics.

A.4.Controlling Measures

- **Thorough Pond Cleaning and Disinfection**

Bleaching powder (chlorinated lime) should be applied at the rate of 50 ppm in the pond.

It readily kills all the wild fish species, molluscs, tadpoles, crabs and disinfects pond soil and water.

In nursery and rearing ponds, it is desirable to use Malathion at the rate of 0.25 ppm 4-5 days prior to stocking of fish seeds.

- **Disinfection of Appliances:**

Nets, gears, plastic wares and Hapas should be sun-dried or immersed in a disinfected solution.

- **Disinfection of Fingerlings and Feeding Platform:**

Disinfection with mild concentration of potassium permanganate solution is helpful during the transfer of the fingerling to stocking tanks.

The feeding platform can be disinfected by hanging bleaching powder cloth bags with mixture of copper sulphate and ferrous sulphate (ratio 5:2) near the feeding place.

When fish come to the feeding place for feeding purpose, their skin will be automatically disinfected.

- **Proper Feeding:**

Fixed quality, quantity, time and place have to be followed for proper feeding.

Any reduction in quality and quantity and variations in feed application and place may cause not only deficiency disease, but also will increase the susceptibility to many infectious diseases.

- **Segregation of year class fish population:**

Brood and older fish may serve as carriers of disease causing organisms without exhibiting any clinical symptoms.

To avoid such risk, young fish should be segregated from the brood and older fish.

- **Spot removal of dead fish from the pond:**

Dead and sick fish should be removed as soon as it is located.

- The daily loss of fish should be recorded to provide valuable insight to the intensity of disease problem. **Chemoprophylaxis:** Effective and inexpensive prophylactic measures against wide range of parasitic and microbial diseases are advisable as chemoprophylaxis. Occasional pond treatment with potassium permanganate at the rate of 2 -3 ppm and dip treatments with potassium permanganate at the rate of 500 - 1000 ppm for 1-2 minutes or short bath in 2-3% common salt solution is safe.
- **Immunoprophylaxis:** Immunization programme is gradually emerging as one of the most important measures for preventing infectious disease.

- Content/Topic 2: chemical prevention measure

A. Compounds and treatment regimes

Table 9: Compounds and Treatment regime of fish diseases

Compound	Treatment Method and Dose Rate	Disease or Agents Treated
Formalin (40% formaldehyde)	Bath:20–45 min,100–250 ppm Bath: Permanent,25–50 ppm	External protozoa and Monogentic trematodes, but occasionally ineffective for some monogeneans
Salt	Bath:Indefinite,0.1–0.2% Bath: 20–30 min., 3.0%	Saprolegnia External protozoa Leeches, Crustacea
Trichlorphon (Dipterex)	Bath: Permanent, 0.25 ppm	Crustacea, Leeches For persistent mono-generals infections, especially Gyrodactylus
Malachite Green	Bath: Permanent, 0.1 ppm	Saprolegnia External protozoa
Copper Sulphate	Bath: Permanent, 0.2–2 ppm dependent on hardness. Do not use in softwater	External protozoa
Potassium Permanganate (KMnO4)	Bath:Permanent, 2 ppm Repeat treatment may be necessary	External protozoa Monogenetic trematodes
Quaternary Ammonium Compounds e.gRoccal, Hyamine	Bath: 1 hr, 1–4 ppm depending on hardness	Mysobacterial skin and gill infections. Skin ulcerations caused by bacteria
Emtryl(M & B)	Food: 4g/100 kg fish/day	Hexamita
Malachite Green/Formalin mixtures	Bath:indefinite,0.1ppm malachite & 25 ppm	External protozoa especially Ichthyophthirius and some monogenetic trematodes
Nifurpirinol (Furanace)	Bath:1hr,1ppm Bath: Indefinite, 0.1 ppm	Myxobacterial infections
Magnesium Sulphate	Food: 3% of ration	Intestinal helminthes
Nitrofurans	Food: 10g/100 kg fish/day for 10 days Bath: 4 ppm	Systemic bacterial infections

Oxytetracycline	Food: 7g/100 kg fish/day for 10 days Injection: 50 mg/kg	Systemic bacterial infections
Sulphonamides	Food: 15g/100 kg fish/day for 10 days	Systemic bacterial infections
Potentiated Sulphonabamides (Tribrissen)	Food: 5g/100 kg fish/day for 10 days	Systemic bacterial infections

B. Sanitary record keeping:

As fish farming progress from extensive to intensive farming, disease incidences tend to increase due to decreased ecological barriers; the outcome of this is increased stress and increased rate of transmission of pathogens. This increases the susceptibility of fish to disease.

B.1.Fish health record

Table 10: Fish health record

Date	Pond/tank n^{o}	Pond/tank size	species	Age of fish	Unusual responses	No dead	symptoms	Action taken

B.2.Zoo-sanitary data collection and interpretation

For a successful diagnosis and proper treatment, accurate information describing the history and characteristics of the fish health problem is vital. Farmers should provide the following zoo-sanitary data:

- Owner and name of contact person, address and phone number
- Surface area and average depth of the pond
- Number, size and species of the fish in the pond
- Water temperature
- Water colour and appearance
- Water quality data, if available
- History of the fish health problem including: number of fish dead, size of the dead fish, species affected, behaviourals signs noted, time course of fish loss, treatment given (what, how, much, when)

- Time of sample collection
- Method of sample collection
- Condition of fish when sampled.

Reference(s)

1. Rutaisire J. Et al., (2009), Fish farming as a business, Fountain Publishers, Kampala.
2. WDA, (2015), CBT Training manual, fish farming/animal health trade, Kigali.
3. fishcount.org.uk/farmed-fish-welfare/rearing-conditions-for-farmed-fish **(retrieved on 1June 2020)**
4. https://www.ratemyfishtank.com/blog/breeding-and-rearing-live-bearing-species-of-fish **(retrieved on 1June 2020)**